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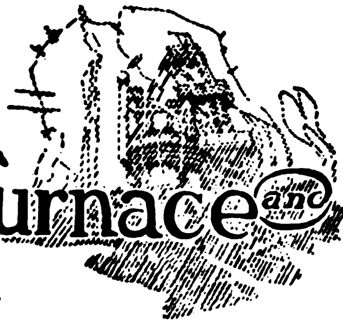
The Blast Furnace and Steel Plant



The Blast Furnace and Steel Plant

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VOL. VII. PITTSBURGH, PA., AUGUST, 1919. No. 8

Rapid Development Indicated in Far East

Communications Received from H. A. Andresen Now on First Lap of World Tour Indicate That China Presents Great Possibilities for Foreign Trade—Japan Formidable Competitor—Notes on Plants.

As announced in the January issue of THE BLAST FURNACE AND STEEL PLANT, H. A. Andresen, president of the National Iron and Steel Publishing Company, started on a world tour during the early part of this year. Sailing from San Francisco he went to Japan where he had the opportunity to meet government officials, industrial leaders and particularly officials connected with the iron and steel industry. The opportunity also was given to visit a number of the leading iron and steel plants in China and Japan. At the present time Mr. Andresen is still in the Far East, however, a number of interesting communications have been received from him. Some of the excerpts and impressions from these communications as presented in these pages throw some light of interest on the general industrial situation in the Far East.

Concerning Japan.

The same marvelous governmental backing which enabled Germany to emerge from an agricultural nation to one of the leading commercial powers of the world, in a period of little over 40 years, has worked wonders in the development of Japan. Poor in natural resources as well as financial wealth, confronted with the problem of a large and constantly increasing population to feed, for which there is only a minimum of arable soil, for generations steeped in devotion to the past instead of the future, Japan has in the short time since her awakening in 1868, worked miracles. Without a single merchantman under her own flag 30 years ago she now possesses a number of large steamship lines, in addition to numerous small ones, which make her one of the leading maritime nations of the world.

Dr. Woo, general superintendent of the Hangyang Iron and Steel Works, and H. A. Andresen, publisher of The Blast Furnace and Steel Plant.

And when one realizes that this development has taken place in a country which for centuries has thought only in terms of small enterprises, so pronounced that this is haled as one of the national characteristics, the wonder is increased.

Today, Japan looms as one of the formidable competitors in the struggle for world trade. Through the foresightedness of her statesmen she is not only approaching a condition where presently she will have a good supply of most essential raw materials, coal and iron ore, but her manufacturing facilities, consisting of large shipyards, machinery and engineering works, electrical establishments, etc., have been improved and increased to a point where before long Japan will not only be independent as regards providing in these lines for her own needs, but will be enabled to build for export. In a country where manufacturing of all kinds has been carried on almost exclusively in the homes of the workmen, and the introduction of the factory system of production is of comparatively recent origin, it is surprising how rapid has been the progress in this respect. Works like, the Anzan Steel plant at Anshanchan, Manchuria, owned by the South Manchuria Railway Company, a Japanese enterprise, have been built entirely in the railway company's model shops at Shahoka (where there is located a model colony that would do credit to any establishment in America) and while it is expected that the steel works machinery, open hearth furnaces, plate and structural mills, etc., will be purchased from England or America, this is only because the Japanese shops are not as yet accustomed to design equipment of this nature expeditiously. That they can build machinery of this character however, is proven in the installation of the steel plant at the Mitsubishi Steel Works at Kenjiho, Chosen, where except for the two 150-ton blast furnaces built by Riter-Conley Company, Pittsburgh, eight McClure hot blast stoves, Wilputte battery of 50 coke ovens, six German gas producers, three Ingersoll-Rand turbo blowers and General Electric generators, the entire steel mill equipment, consisting of two 50-ton open hearth furnaces, a 58-inch plate mill, structural mills and blooming mills and entire crane equipment, housed in a magnificent concrete building is built by the Shibaura Engineering Works, Tokyo. This plant has just started to produce steel and will for the present only smelt about 50 per cent of its pig iron capacity, it is expected that within a short period, despite the fact that it was built during war times and at war prices, that it will produce iron and steel as economically as the big government plant at Yawata, to which it is next in size.

From the standpoint of exporting goods, except raw materials, Japan can not be figured upon as a big possibility, but with cheap labor and better production facilities Japan will be a tremendous import market, particularly when the Japanese learn how to turn out higher grade merchandise in larger quantities. Progress in this respect is being continually made.

In the following paragraphs some information concerning the Yangste Engineering Works, the Hankyehping Iron and Coal Co., Ltd., and the Anzan Steel Works is given.

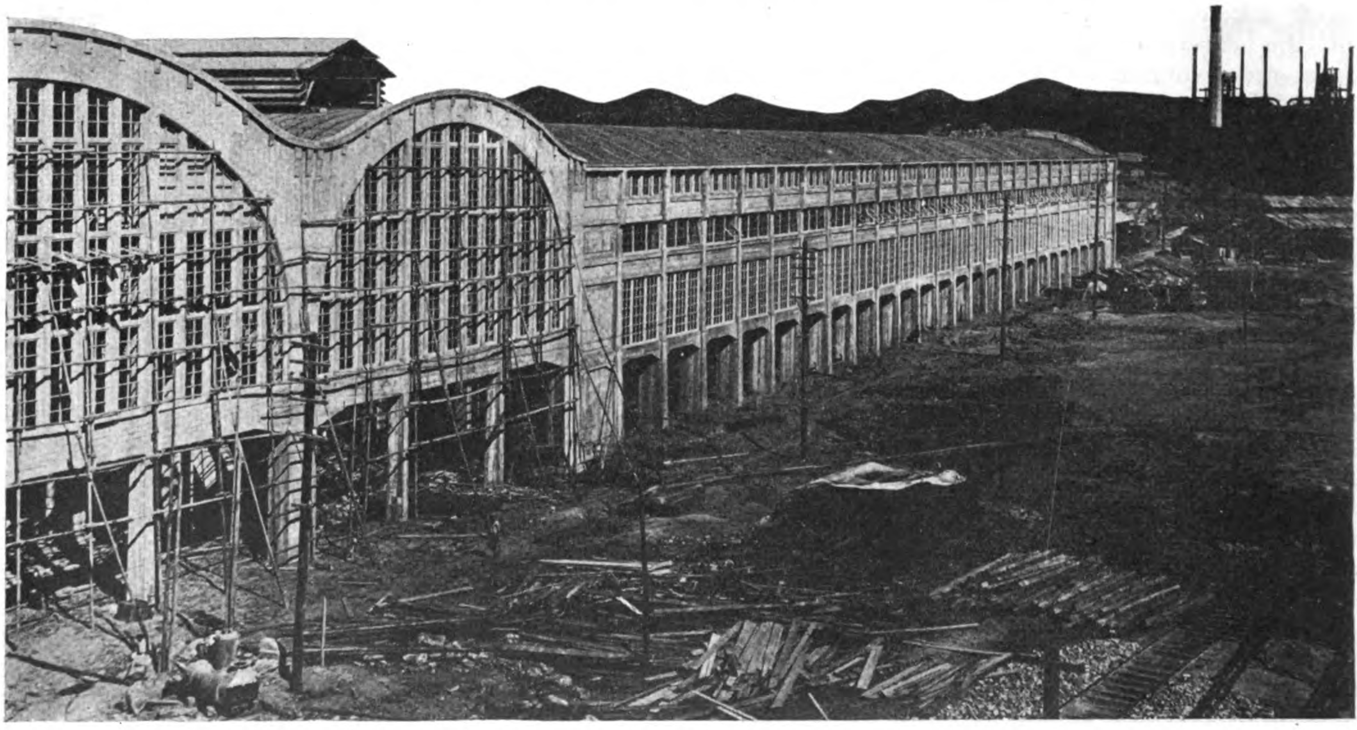
Yangste Engineering Works.

The Yangste Engineering Works at Hankow, China, are now building a 100-ton blast furnace of their own design and expect later to install a small Siemens-Martin open hearth furnace for conversion of iron and steel for their own use. This company which is wholly a Chinese enterprise has heretofore been operating a fabricating and bridge shop, and while still small as steel plants go bids fair to be a growing institution. This with the exception of the Hangyang Iron and Steel Works is the only Chinese iron and steel plant making modern products.

Hangyehping Iron and Coal Co., Ltd.

The site of the Hangyang Iron and Steel Works was originally selected by a viceroy of Hupeh Province in 1892, who desirous of having a Chinese iron and steel foundry, as they call it, selected this site without reference to either ore or coal resources. Subsequently ore was discovered at Tayeh, 48 miles down the river, a very rich and the largest deposit in China, and the coal brought from Pinghsiang, near Changsha, about 316 miles south of Hankow, by junks and lighters. Railroads will soon be used, thereby reducing cost. The entire property is owned by China, under the name of the Hangyehping Iron and Coal Company, Ltd. On account of revolutions and failure to secure sufficient money from the government Japanese banks have loaned money to the extent of 15,000,000 yen, to the Hangyehping Iron and Coal Company, as a result of which the Imperial Government steel plant at Yawata has secured an advantageous contract for both ore and pig iron, and some steel. The demand in China for steel products is far below the tonnage produced at Hangyang.

The plant consists of two 100-ton blast furnaces, German design, and two 250-ton furnaces, built about five years ago, also of German design, and seven 30-ton ope nhearth furnaces, German design. The turbo



Concrete building housing plate and structural mills. Mitsubishi steel plant Kenjiho, Chosen. This building is excellently constructed and is modern in every respect.

blowers are from Parsons, Ltd., England, as is also most of power plant machinery. Coke is made by old fashioned rectangular beehive practice at Pinghsiang. The steel plant has two bar mills, a plate mill and a structural mill, where angles, channels and some other shapes are rolled. This firm also has its own brick plant, making silica and firebrick. New 400-ton furnaces, shipped by Riter-Conley, Pittsburgh, Pa., are to be built at the Tayeh mines, where eventually the real steel plant will be built, this being the better location.

Anzan Steel Works.

On May 1, 1919, the new works of the Anzan Steel Works commenced operation.

The Anzan Steel Works was conceived and planned by Lieut.-Gen. Baron Y. Nakamura ex-governor-general of Kwantung and ex-president of the S. M. R. Co.

The iron mines of Anzan were made exploitable by virtue of the Sino-Japanese treaty with South Manchuria concluded in May, 1915. A company was organized under Sino-Japanese joint management under the style of the "Chenhsing Mining Company." The ultimate plan of the new plant is to turn out 1,000,-sively by the S. M. R. Co. The grand plan of the new steel works was put in execution in autumn of 1916. The ultimate plan of the new plant is to turn out 1,000,000 tons of pig iron annually and to manufacture it into steel.

As the work for the first part of the program, two smelting furnaces capable of yielding 150,000 tons of pig iron per annum were to be constructed, and equipments were to be installed to manufacture the output into steel.

How the S. M. R. Company came to select Anzan for the seat of the new gigantic plant has been criticized by some people and even the deferment of the building of the first fire in the grate has been made a theme of insinuating remarks. However, all these are only the offspring of superficial observations, and the fact is that the most careful study of the subject was made in deciding the seat of the steel works.

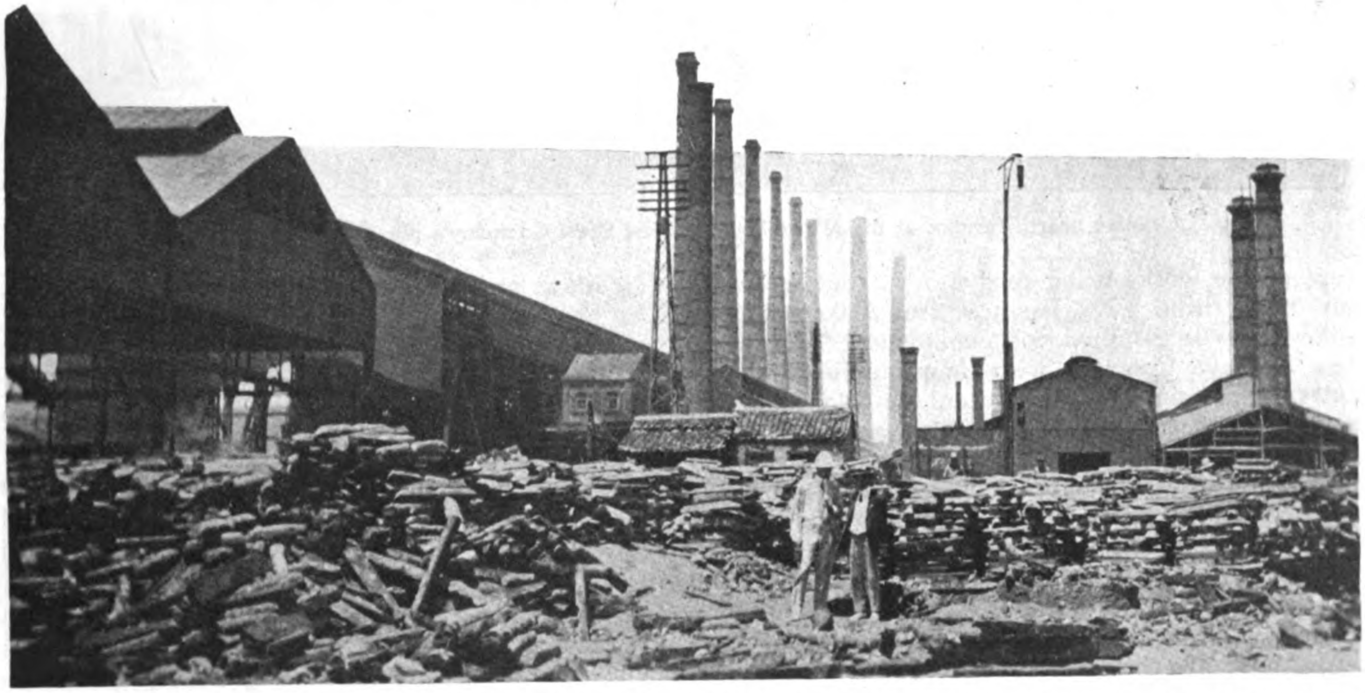
The first requisites for a steel works are water supply and fuel. The success of the enterprise may be considered to depend upon the facilities for obtaining these two requisites. However, with ample facilities for the supply of the two primary requisites, the place must not be damp, or threatened with a flood. From these considerations, the present site of Anzan is excellently suited for the purpose.

In course of time, water supply will have to be drawn all the way from the River Taitzu, 16 miles away, running north of Liaoyang, but to answer the needs of the first part of the program, temporary arrangements have been constructed on the bank of the River Chienshan and also at the foot of Shoushan, famous as the key to the Russian strategic situation in the battle of Liaoyang in 1904. Reservoirs have been constructed at both places for the purpose. An idea of what an important factor water is in iron manufacturing may be had from the fact that for the operation of two smelting furnaces 20 tons of water are required per minute. The necessary water supply for the two furnaces would be enough for a population of 500,000.

Next, as regards coal, Fushun coal will form the principal part of supply to be mixed with Penchihu coal in a minor portion. For the first part of the program, 400,000 tons of coal will be wanted annually.

When in future the works is ready to put out 1,000,000 tons of pig iron, and 2,800,000 tons of coal will be required annually.

Then as to the iron mines, the first mines to be tapped are Yingtaoyuan, Takushan, and Hsi-Anshan out of altogether eight mining zones. Yingtaoyuan



View of exterior of Hangyang Iron and Steel Works, China. Dr. Woo and H. A. Andresen inspecting the company's plant.

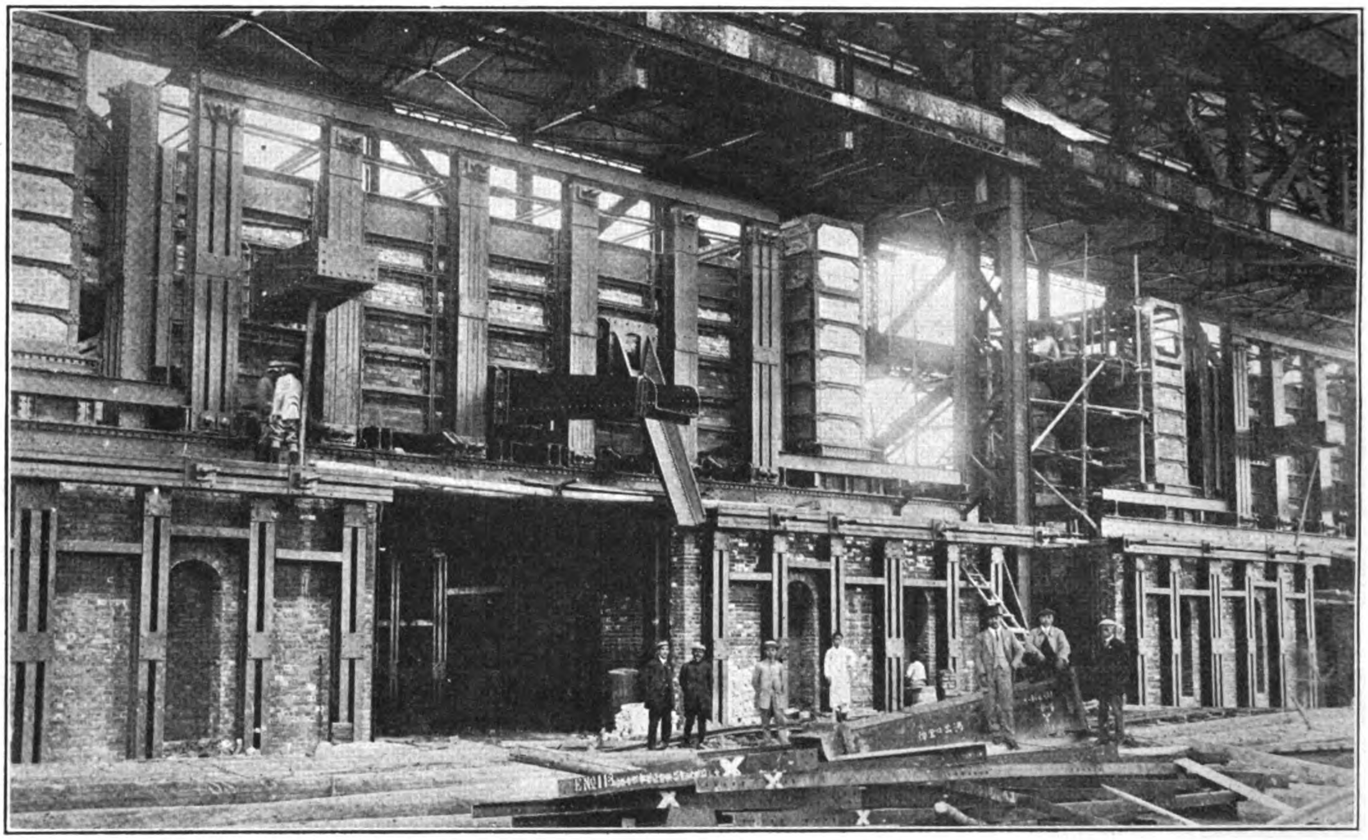
produces ore containing from 60 to 65 per cent iron while the other two give ore containing 40 per cent iron.

What the exact amount of iron ore will be is a matter of scientific estimation. It is put at between 100,000,000 and 150,000,000 tons. Figuring the average percentage of iron at 40 and on the basis of the annual output of 1,000,000 tons of pig iron, 2,500,000 tons of iron ore will be wanted annually and at this rate the iron mines will last 75 years.

The S. M. Railway Area about the Anzan Steel Works comprises 4,000,000 tsubo, of which 2,400,000 tsubo is set apart for the works colony and the remaining 1,600,000 tsubo is for the works itself. The works colony is planned on the estimated capacity for a population of from 100,000 to 150,000. In the event of the works being ready to put out 1,000,000 tons of pig iron, 8,000 Japanese and 30,000 Chinese coolies will be required for employment. Figuring these employes together with their families and the tradesfolk catering for their needs, the colony plan is said to have been drawn up. In the extensive works compound, which contains two railway stations of Anshan and Lishan, the former is to be used principally as passenger station and the latter as goods station.

The works colony is laid out at Anshan. At present straggling houses are scattered here and there in the expanse of level plain, but according to the plan, the area lying on the east of the railway is alloted to the Japanese and that on the west of the railway to the Chinese. Already there are 5,000 Japanese and 15,000 Chinese connected with the steel works directly or otherwise. The primary school has a roll of 500 children.

Scarcity and dear prices of building materials are felt keenly at Anshan as elsewhere in South Manchuria. These are the most acutely felt by the Manchuria Development Company, Ltd., which originally intended to erect houses for rent under its own management in addition to others contracted for with the S. M. R. Company for residential purposes, but has been obliged to defer this plan to future date. There are many who are said to be in a similar dilemma among the lessees of land at the works colony and a good number of them who rented tracts of land during the first offer will have their leases cancelled next June on the ground of the failure to complete building work as provided for in the lease contracts.



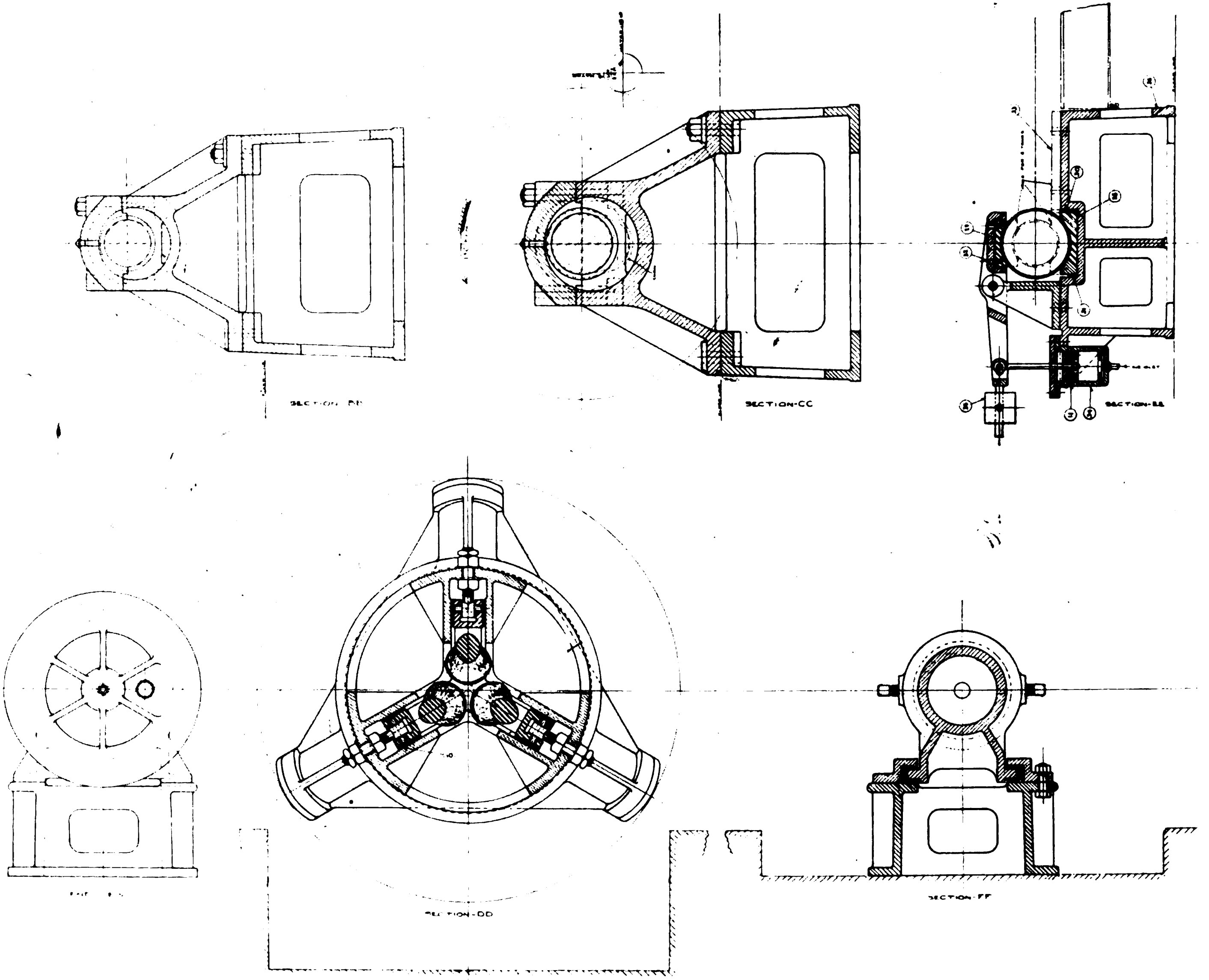
Open hearth furnace at the Mitsubishi Iron and Steel Company's plant at Kenjiho, Chosen.

The location of the steel works has been selected not from the consideration of proximity to the iron mines, nor from that of water supply facility. The facilities for the transportation of sundry materials to the works and of its outputs to the seaboard have had the controlling voice in the choice of the present site, and all being considered, this choice is affirmed by all concerned to have been a sensible one especially as the final decision rested with Lieut.-Gen. Baron Y. Nakamura (then president of the S. M. R. Company) whose clear-headedness and ripe experiences in steel manufacturing are acknowledged by everybody who has had the privilege of knowing him.

Forming Machine for Shaping Steel Tubes

Production of Tanks Suitable for the Commercial Transportation of Explosive Gases and Liquids Facilitated by Machine in Which Work Is Spinned While Applied Against Nest of Three Rolls.

The forming of various shapes of noses on steel cylinders, tubes and tanks, suitable for the commercial transportation of explosive gases and liquids, has been rather an expensive process compared to the manufacture of the article proper. This is due to the many operations that have to be performed, and consequently, the excess labor and heating that has to be employed to get larger quantities.



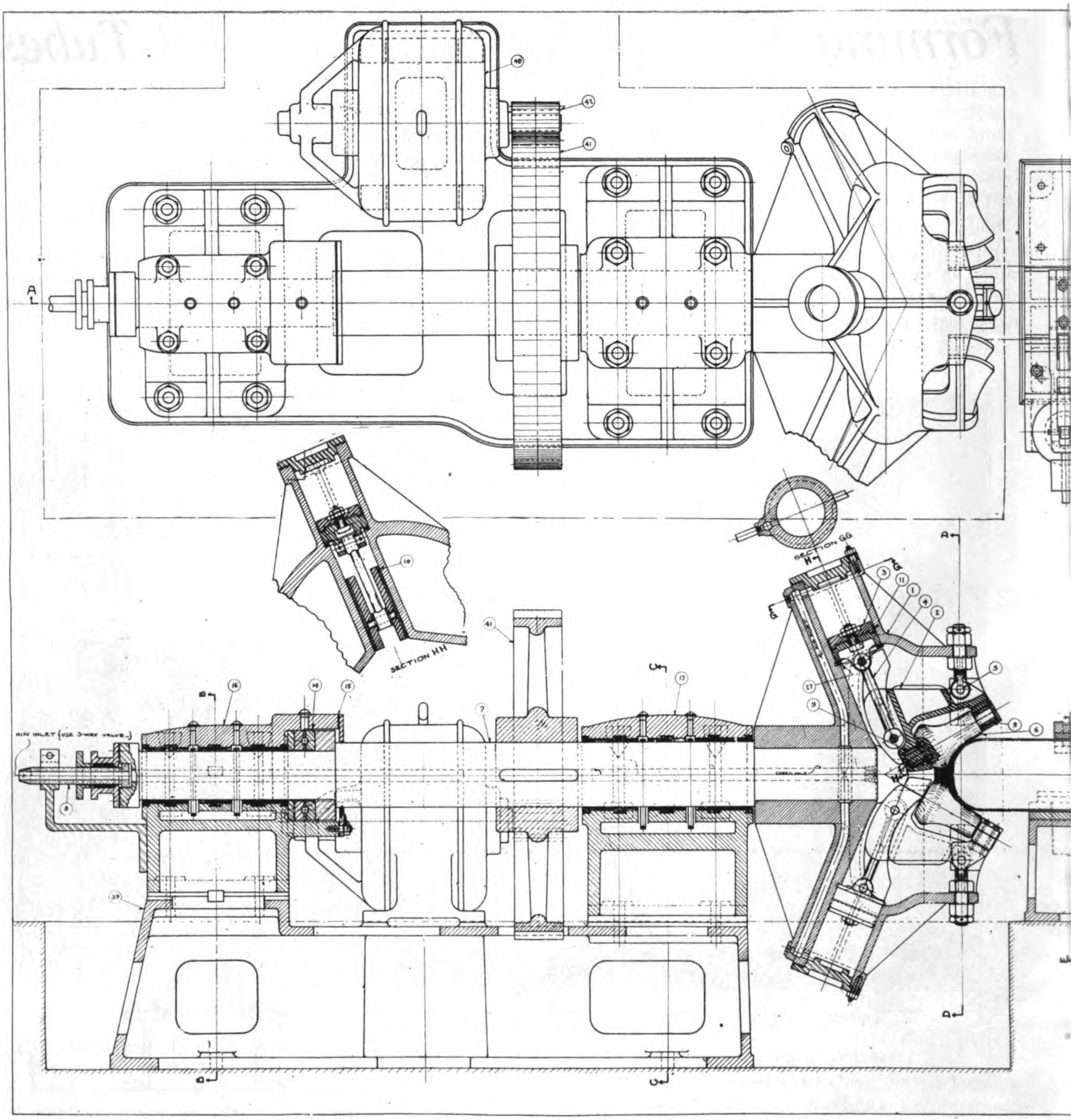
Several sections of the nose-forming machine. The plan view and section through the entire machine is shown on pages 370 and 371.

In order to facilitate production and to form a more perfect nose at a comparatively small cost, Walter Ferrier, now general superintendent of the Elyria Iron & Steel Co., Elyria and Cleveland, O., has conceived the idea of spinning the work while applied against a nest of three rolls, 120 degrees apart.

The machine shown in the accompanying illustration is his most recent development which embodies many distinct features designed to assure accurate work and maximum output.

The following description covers, practically, the principal of the entire mechanism and the two drawings, A and B, show all parts assembled, in section.

Referring to the drawings, particularly to the roll housing and chuck with its attendant operating mechanism, there is shown: "Section AA," "Section DD,"

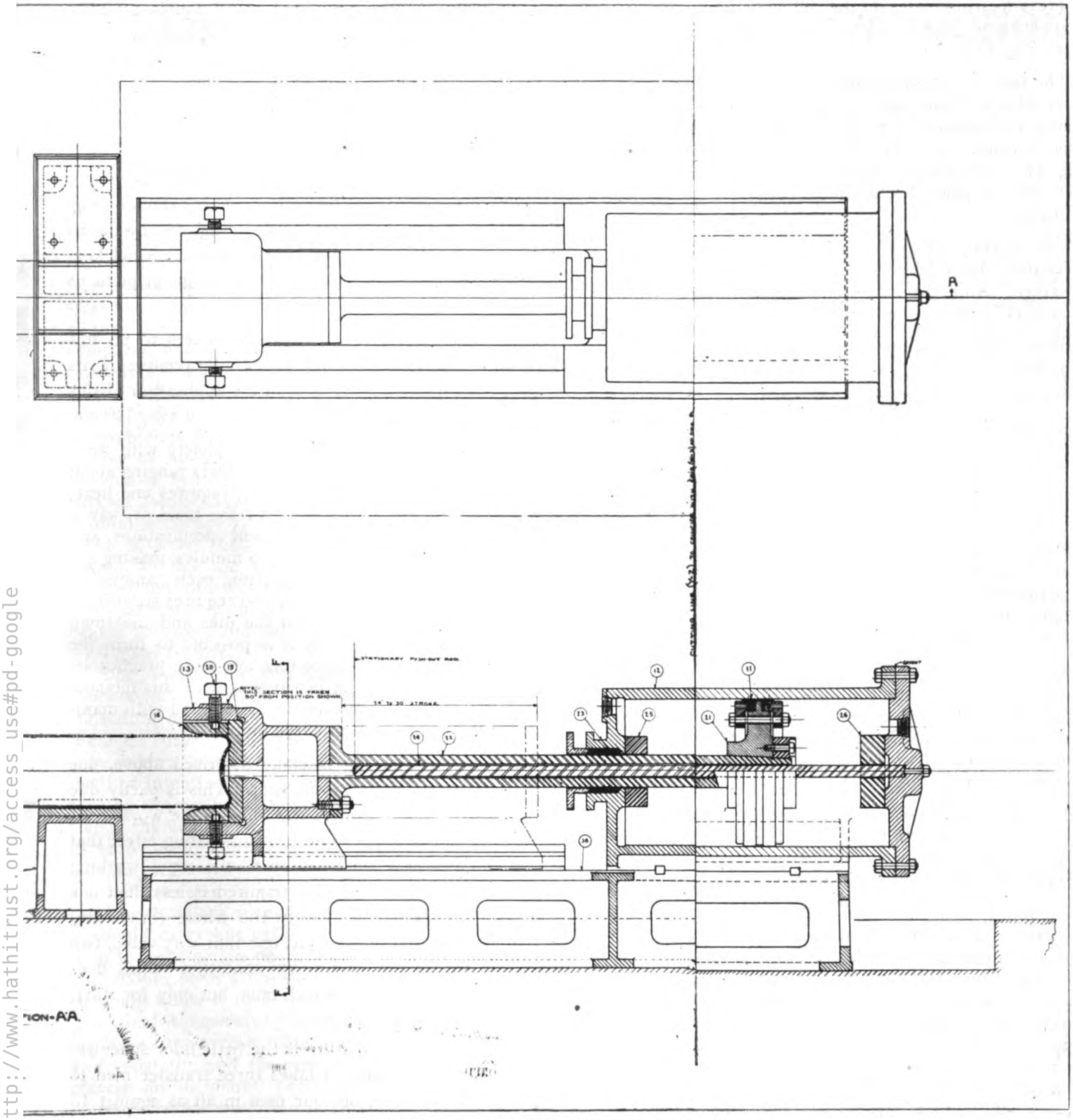


"Section GG," "Section HH" and "Plan View," the principal of this design.

It consists of operating the rolls on the surface of the partly-formed nose so that by skin friction the top surface of the wall will not be elongated or pulled relative to the inside surface, but rather form the nose so that the tank will neither increase or decrease in length and thus make the area of any transverse cross section of the nose equal and the same as that of the tank or tube itself, thus putting sufficient metal at the neck to permit of drilling and tapping out.

This is done by pivoting the roll containers (Fig. 2) on one end, as shown, (Fig. 5) and operating the other end pneumatically by the direct expansion process. (Piston, Fig. 3.)

The three air cylinders are cast in one piece with the housing (Fig. 1) equidistant apart (120 deg.) and at equal angles with center lines converging at the same point in the center. Here it should be noted that the angle of the line HH is such that when the rolls are in their open or receiving position, i. e., when their axes are horizontal, the connecting rod (Fig. 4) is again in same



angle and center line as shown in section, thus always actuating in the direction of greatest available pressure or force.

When the rolls (Fig. 6) are closed or in the position shown on drawing they make an angle of 30 degrees with the horizontal and are always acting in planes radially equidistant apart. Their tendency is to always approach the horizontal or open up by virtue of the centrifugal force induced by the revolving housing.

This force is counteracted, of course, by the air pressure in the cylinders immediately upon application.

This housing with its nest of rolls is revolved by means of a hollow shaft (Fig. 7) at about 130 rpm driven by a 10 hp motor (Fig. 40) through gears (Figs. 41 and 42).

A cored hole through the shaft is provided to admit the air by means of a stationary gland connection at the outer end (Fig. 8) to the three pneumatic cylinders (Fig. 3) operating the rolls. The air ports leading from the annular groove in the hub and the three radial holes emanating from the center core of the shaft can be seen in sections AA and GG.

Note the Hyatt roller bearings for rolls (Fig. 9) and the brass wearing plates on the roll containers (Fig. 10). All pneumatic pistons to have leather cupped packing rings (Fig. 11).

The tank is forced against the action of the rolls by means of a high pressure pneumatic cylinder (Fig. 12) through the medium of a sliding chuck (Fig. 13). This thrust is counteracted by means of a ball thrust bearing (Fig. 14) well enclosed, dust proof, and with the gasket (Fig. 15) in place forms an oil reservoir for proper lubrication.

The bearings (Figs. 16 and 17) are practically self-explanatory by referring to sections BB and CC respectively. Note the key dowelling the thrust bearing pedestal (Fig. 16) to the bed plate.

These bearings are mounted on a common bed plate (Fig. 39) with the motor to reduce the vibration caused by the revolving housing to a minimum.

Section FF shows the sliding shoes and a transverse view of the sliding chuck. The grip jaws (Figs. 18 and 19) are of tool steel and are adjustable by means of screws (Fig. 20) and interchangeable to suit the contour of the base and diameter of the tank or tube to be nosed.

This sliding chuck is directly connected to the main piston (Fig. 21) with a hollow steel rod (Fig. 22) flanged on the chuck end, and sliding through a properly packed gland (Fig. 23). This piston rod slides back and forth over a smaller stationary push-out rod (Fig. 24).

Regardless of the length of stroke of the main ram the end of the push-out rod (Fig. 24) must extend at least six inches beyond the back end of the stroke so as to push the tank out of the jaws completely before the piston comes to the back end of its stroke or in the position ready for receiving.

The liners (Figs. 25 and 26) are for adjusting the stroke to a minimum to avoid the waste of air unnecessarily. So also is a liner (Fig. 27) provided in housing roll cylinders to govern the length of stroke to accommodate the small diameter of neck required.

After the tank is placed in line, but before nosing, it has to be clamped as shown by Section EE to prevent the neck from being formed out of true alignment. This section also shows the wearing contour plates (Figs. 28 and 29), the top one fastened by means of cap screws (Fig. 32) and the bottom one with wooden wedges (Figs. 30 and 31). The dot and dash lines show how these jaws can be interchanged (see also Fig. 33) to suit six-inch or any size tank within reasonable limits for which the machine is designed.

This clamp is operated pneumatically also by means of an air cylinder (Fig. 34). Immediately after the air pressure is released in the cylinder the clamp automatically opens up aided by the counterweight (Fig. 35) or gravitation.

The stand (Fig. 37) (Section AA) is similar to stand (Fig. 36) (Section EE) and is necessary to support tank when rolled in position ready for pushing in the jaws of the rolls.

The main cylinder (Fig. 12) being double acting is controlled by means of a four-way valve, and the air inlet through main shaft to roller cylinders is controlled by a three-way air valve since they are only single acting.

Also the sliding chuck (Fig. 13) is mounted on a common bed plate (Fig. 28) with the main cylinder (Fig. 12) to insure perfect alignment relatively.

Here it may be noted that the main air cylinder (Fig. 12) is also dowelled on its bed plate (Fig. 38) by means of a key which can be shifted forward to a second keyway placed to suit the best stroke for a given piece of work.

Most manufacturers use steam hammers to do this work now and it is interesting to note the relative merits of the steam hammer process with the application of this new machine.

Ordinarily the nose is formed completely with three sets of dies, requiring three steam hammers ranging about 400 pounds each. Each die working requires one heat; hence it takes three heats to form the nose of, say a nine-inch gas tank, as per government specifications, and each operation averages at least two minutes, making six minutes in all, and two men operating each hammer or six men to complete the nose. It also requires six men to transfer the tanks to and from the dies and the small heating furnaces. Of course it is possible to form the nose with two dies, but three dies are more practicable. Therefore, in order to get production with this method, 12 men must be used and three heats required with maximum output of one tank in two minutes.

Now with the rolling machine described above, one such tank can be nosed in one heat. This is partly due to the effect of the action of the rolls on the work, i. e., the rolls do not have the rapid heat dissipating effect that the closed dies have, and mostly to the rapid working effect on the metal. The time required is less than one minute. One man can operate the whole controlling mechanism which is very simple, one four-way valve, two three-way valves and one motor controller which does not have to be operated for each tank, but only for starting and stopping the machine.

Another desirable feature is the little floor space required. Therefore, since it takes three transfer men to and from the furnace, or four men in all as against 12 men before, it can be seen that with this machine four men can make nearly 100 per cent more production than 12 men can by using the steam hammer processes, and besides there is a remarkable saving in heating capacity, steam and floor space.

The drive is a variable speed motor of 10 hp with one gear reduction. When running at full capacity the machine requires an air supply of about 10 cubic feet per minute at a pressure of 100 to 120 pounds per square inch.

Modern Steel Metallurgical Calculations

Methods of Calculating the Consumption of Materials and the Technical Results in the Manufacture of Steel from Any Kind of Pig Iron by Any Standard Process.

By CHARLES H. F. BAGLEY.

PART I.

The object of this paper is to present a simple and reliable method of calculating the consumption of materials and the technical results in the manufacture of steel from any kind of pig iron by any standard process, so that their relative advantages can be estimated and compared with some degree of confidence, instead of remaining simply matters of opinion and experiment. In the "heavy" steel trades the final cost of the ingots must always be the leading factor, and the best method of producing them cheaply in any district should be a matter of no uncertainty. The system described is essentially synthetic rather than analytical, involving various assumptions in lieu of precise data; but its substantial accuracy is confirmed by the general agreement between the calculated figures and the actual results by all the standard processes. The author worked out this system some years ago for his own use—particularly in connection with the basic open-hearth process—and has constantly employed it since with good results.

Slag Formation and Character—In any refining process involving molten materials a slag is formed consisting essentially of the products of the elements removed (other than gases) in combination with suitable fluxing material (either derived from the metal itself or intentionally added)—together with a proportion of the active reagents employed, for which this slag is the vehicle. These constituents must be present in such proportions that they are mutually self-fluxing and self-satisfying at the prevailing temperature: so that the slag is reasonably fluid and inactive on the hearth of the furnace. At the end of the process it should carry but little excess of the active reagents—so that its action on the metal has almost ceased—and should have a physical consistency and condition that will allow it to be easily separated and removed. The final temperature is governed by the physical requirements of the metal—which are fairly definite and constant; and the composition of the slag, being merely an incidental product, must be regulated to suit so that its condition is right at tapping temperature of the metal. In the molten state, such a slag may be considered as essentially a complex solution of acids and bases rather than a definite chemical compound; their proportions being determined by the temperature, and the valency of the constituents as acids or bases, rather than by definite chemical formula—regardless of whatever definite compounds may be crystalized out later. In steel melting no great range of finishing temperatures is permissible, and the physical conditions of both metal and slag are fixed within comparatively narrow limits, within which the slag may be neither too thick nor too thin, and its composition is, therefore, fixed within a similar narrow margin, if its condition is to be satisfactory. It has always been the custom of practical men to judge of the progress of operations, and the quality of the metal, by its fracture and by the appearance of the slag, a method which, though apparently primitive, is thoroughly sound and practical, affording to the experienced man a visual indication of the actual physical conditions obtaining. It is almost an axiom in practice that if the slag be right, the metal also will be right.

Acids and Bases—In a steel slag, the chief constituents—none of them individually very fusible—may be grouped into two main classes—acids and bases—which mutually flux and neutralize each other at quite moderate temperatures when present in approximately equal proportions. At higher temperatures a slag often becomes too thin and active and attacks the fettling material of the hearth; the proportions must then be altered to raise its melting point and reduce its fusibility correspondingly. An excess either of acids or bases is required, according to the nature of the hearth material, beyond the proportions required for fusibility at moderate temperature—as, for instance, for a mixer slag—and if not already present must be supplied by suitable additions, failing which, the slag will help itself from the hearth materials until it is "satisfied" or approximately neutralized at that temperature. The schedule of steelworks slags given later illustrates the point very clearly, and is worth careful attention. The figures quoted are for final or tapping slags only, and are taken from actual practice at many different works in England, Germany, and America operating on various irons, by various processes, under very varied conditions. They may be taken as fair averages for good practice, whatever the pig iron. For calculating purposes, the composition of the slag as run to waste—usually the tapping slag—is the only possible basis, regardless of what it may previously have been. During the slag formation period and at early stages of the process, it is in a state of constant chemical activity and change until its active reagents, FeO and Fe_2O_3, approach exhaustion. Its composition will vary considerably, therefore, according to the extent and nature of the additions made, the progress of the reactions, and the temperature conditions of the moment. Slags from continuous processes—such as refining mixers, in which there is no finality—are always irregular, and many vary within wide limits for the same reasons. The

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From paper read before British Iron and Steel Institute.

final slag as run to waste is thus the only sound basis for calculations; and whether run off on tapping or before, it should carry a minimum of free oxides, together with the maximum of acids permitted by the temperature at that period.

As regards the various constituents, it may be noted that they are nearly all oxides—usually the lowest oxide the element is capable of forming; and some of them, notably those derived in part from the metal, are therefore capable of being partially reduced in the later stages by the remaining carbon of the bath, especially in the absence of sufficient free oxide of iron. Not only has the slag an oxidizing effect on the metal, but the metal and its metalloids have an equal reducing effect on the more active constituents of the slag. A general principle is that any element which is reducible in the blast furnace is oxidizable in the steel furnace or converter and removable as an oxide in a suitable slag containing some constituent with which it can enter into combination—failing which it will be again reduced by the remaining carbon of the bath, unless an excess of some more reducible oxide—say Fe_2O_3, FeO—is present, when it may be partly removed as an oxide in the slag. The iron oxides may be used to limit the extent of its reduction, but will not alone entirely prevent it. In any case, the reducing influence is always present, and tends to prevent the entire elimination of any element, at least until the carbon is gone, and traces of them all are usually found in the finished steel. In the acid process 0.02 to 0.04 per cent of silicon and 0.03 to 0.06 per cent of manganese are usually found, either never oxidized or subsequently reduced; and, in the basic process, traces only of silicon and 0.10 to 0.40 per cent of manganese are found. The difference arises from the fact that MnO has a great affinity for SiO_2 which is present in excess in the acid slag, and little MnO is therefore reduced. In a basic slag, however, there is no excess of SiO_2, and the MnO is more liable to the reducing influence of the carbon. Quantitatively these traces are almost negligible and have no material effect on the calculations, but they affect the general quality or condition of the steel considerably and account largely for the characteristic differences between steels made by various processes.

Steelworks Slags.

It may be objected that the average acid contents here shown are on the high side in some cases—especially for basic slags from fixed open-hearth furnaces—and set a standard not always reached in practice. This may possibly be so, the result being to show these processes rather too favorably, but for the sake of comparison between basic open-hearth processes, the slags are all placed on the same level. It also seems useless to compare poor practices together, and where actual results fall short of these figures—which often are realized—there appears to be room for improvement. It is frequently observed that one charge takes considerably more lime than another, though using the same quality and quantity of iron, especially if worked slowly or delayed for any reason, constant fresh additions being needed to keep the slag in proper condition and prevent it from getting thin. In these cases, the total acids are invariably low—possibly down to 18 per cent or less—and the CaO higher than here shown—possible up to 58 per cent—under which conditions the lime consumption may be as much as 75 per cent above normal. The subject will be more fully dealt with later when considering the removal of sulphur and the production of phosphate slags.

Normal Steelworks Slags.

Process Pig Iron Additions Normal variations	Acid Bessemer. Hematite. Nil. Range Mean	Acid Open-Hearth Hematite. Oxides. Lime. Range Mean	Acid Open-Hearth Hematite. Oxides only. Range Mean	Acid Mixer. Any Iron. Oxides. Lime. Range Mean	Basic Mixer Any Iron. Oxides, Lime. Range Mean	Basic Open-Hearth Hematite. Oxides. Lime. Range Mean	Basic Open-Hearth Common Forge. Oxides, Lime. Range Mean	Basic Open-Hearth "Thomas." Oxides, Lime. Range Mean	Basic Bessemer. "Thomas." Lime. Range Mean
SiO_2	62/68 = 65.0	57/63 = 60.0	48/52 = 50.0	38/46 = 50.0	36/42 = 39.0	25/29 = 27.0	14/22 = 18.0	10/14 = 12.0	6.0/10.0 = 8.0
P_2O_5	....	....	....	....	0.5/1.5 = 1.0	0/2.0 = 1.0	7.0/13 = 10.0	14/18 = 16.0	18.0/22 = 20.0
Al_2O_3......	4.0/6.0 = 5.0	12/18 = 15.0	5.0/9.0 = 7.0	9.0/15.0 = 12.0	0.5/1.5 = 1.0	1.0/3.0 = 2.0	1.0/3.0 = 2.0	1.0/3.0 = 2.0	....
CaO					40/48 = 44.0	46/50 = 48.0	46/50 = 48.0	46/50 = 48.0	48/52 = 50.0
MgO.......					5.0/7.0 = 6.0	4.0/6.0 = 5.0	4.0/6.0 = 5.0	4.0/6.0 = 5.0	4.0/6.0 = 5.0
MnO	8.0/12.0 = 10.0	5.0/15.0 = 10.0	5.0/15.0 = 10.0	4.0/8.0 = 6.0	4.0/6.0 = 5.0	4.0/12.0 = 8.0	4.0/12.0 = 8.0	4.0 / 12.0 = 8.0	4.0/12.0 = 8.0
FeO	18/22 = 20.0	12/18 = 15.0	28/38 = 33.0	35/45 = 40.0	3.0/5.0 = 4.0	5.0/14.0 = 9.0	5.0/14.0 = 9.0	5.0/14.0 = 9.0	5.0/14.0 = 9.0
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total acids	65.0	60.0	50.0	42.0	40.0	30.0	30.0	30.0	28.0
	= 1.86/1.00	= 1.50/1.00	= 1.00/1.00	= 0.725/1.00	= 0.666/1.00	= 0.43/1.00	= 0.43/1.00	= 0.43/1.00	= 0.39/1.00
Total bases	35.0	40.0	50.0	58.0	60.0	70.0	70.0	70.0	72.0
Approximate finishing temperatures °C.	1500/1600	1400/1500	1400/1500	1200/1300	1200–1300	1400/1500	1400/1500	1400/1500	1500/1600

Method of Calculation.

By whatever process effected, the essential operations of steel melting are:

1. The oxidation of the impurities of the raw pig iron.
2. The safe removal of the products—as slag.
3. The maintenance of a temperature high enough to keep the metal molten and allow it to be cast into moulds.
4. The formation, or provision, of a slag of proper physical consistency—fluid and approximately neutral to the lining of the hearth at the finishing tempera-

ture of the process—and finally almost exhausted of active reagents.

Oxidation Table—For a quantitative account of the process and results, the weight of the metalloids to be oxidized may first be considered. From the average composition of charge, it is a simple matter to calculate the weight of oxygen required and of the products formed. Whatever the source of this oxygen, these quantities are fixed and definite and in simple chemical proportions. Thus, the oxidation of:

One unit of carbon requires 16÷12=1.33 of oxygen, forming 2.33 of CO gas

One unit of silicon requires 32÷28=1.14 of oxygen, forming 2.14 of SiO_2

One unit of phosphorus requires 80÷62=1.29 of oxygen forming 2.29 of P_2O_5

One unit of manganese requires 16÷55=0.29 of oxygen, forming 1.29 of MnO.

Units—The units employed may be anything from molecules to tons, but throughout these calculations ton units are employed; and 100-ton charges are considered, so that each 1.00 per cent by analysis represents 1.00 ton, and the decimal system is thus retained throughout, with its customary advantages. Calculations are accurate to the third figure, and approximate where given to the fourth—ordinary slide-rule limits.

Oxides—The oxygen required can be calculated to its equivalent in air, or, subject to certain reservations, in pure Fe_2O_3, or its equivalent in ore of given analysis; and the weight of the metallic Fe, etc., introduced therewith is easily found. The other items, SiO_2, P_2O_5, Al_2O_3, CaO, MgO, MnO, etc., also introduced, may often be important, especially SiO_2, as compared with the amounts derived from the metal itself, and should be taken into account in calculating the slag make and analysis, lime consumption, metallic losses, yield, etc. The consumption of oxides thus ascertained should be the maximum in good practice, and should rarely be actually reached, as a proportion of the metalloids will always be oxidized by the flame in an open-hearth furnace. Nevertheless, it is often exceeded, especially in hot metal processes—notably in Monell practice—with excessive slag production and needless waste of oxides and lime in the form of half-spent slag. The actual oxide requirements for a given charge or furnace are thus somewhat variable, but for the sake of uniformity they are taken throughout at the full calculated values—which point should not be overlooked when the subject of metallic yield and losses comes to be considered. When cold pig iron and scrap are to be used, allowance must be made for the inevitable metallic loss incurred in melting down; and the oxide formed—as Fe_3O_4—should be deducted from the requirements of the charge. It should be noted that there is usually a small percentage of Fe_2O_3 as well as of FeO to be found in the slag—even towards the end—indicating that although FeO may be in process of reduction by the carbon of the bath, it is simultaneously being oxidized to Fe_2O_3 by the flame to a small extent. This catalytic action partly explains the fact that some charges do not actually use nearly so much oxides as their calculated requirements—which is found to be the case especially with a slow furnace or a dull heat. On the other hand, a keen furnace will take almost its full calculated quantity—indicating that the oxide is quickly reduced and so is not exposed in sufficient quantity nor long enough to the oxidizing action of the flame to allow this catalytic action to occur to any great extent.

Products—The products of oxidation, other than CO and CO_2 which escape as gases, will all pass into the slag, besides the impurities introduced from outside sources—lime, oxides, sand on pig iron, wear of furnace hearth and linings, etc. For the sake of uniformity, this last item is omitted throughout on account of its irregularity and uncertainty, though it is by no means always negligible. The other factors are taken as constant throughout, at the following values:

Cold pig iron—sand allowance at ¼ cwt. per ton = 1.25 per cent SiO_2.

Kirunavaara ore (C) at 65.0 per cent Fe and 3.0 per cent SiO_2.

Burnt lime (C) at 96.0 per cent CaO and 2.0 per cent SiO_2.

Slag Make—In a normal tapping slag of proper temperature and consistency there is no great range of variation in composition, and the total weight of acids present will therefore determine approximately the average make of slag. Thus, if the total SiO_2 produced from 100 tons of iron by an acid Bessemer converter be 6.30 tons, and the final slag normally contains 63.0 per cent SiO_2, the average make of slag will be 6.30 ÷ 0.63 = 10 tons per 100 tons of iron. So also in the basic process, if the total acids SiO_2, P_2O_5 from 100 tons of iron plus that introduced by the necessary lime and oxides amount to 5.60 tons, and the final slag normally contains 28 per cent of acids (SiO_2 and P_2O_5), the average make of slag will be 5.60 ÷ 0.28 = 20.0 tons. In preliminary refining or mixer furnaces, taking into consideration the acids produced and the normal acid contents of the slag made (as controlled by the working temperature), the same applies. At particular works the final slags may vary in acid contents from the figures shown in the schedule of steelworks tapping slags here given, and the basis of calculation will require amending accordingly, but the principle still holds good and the average results will be reliable.

Lime—The burnt lime required is at once found from the average make of slag as above, taking into consideration the CaO contents of the lime, which rarely exceeds 96 per cent. Thus, for an acid slag to contain 9.6 per cent CaO, the burnt lime needed will be 9.6 ÷ 96 = 10 per cent of the slag made; and for a basic slag, to contain 48 per cent CaO, the burnt lime required will be 48 ÷ 96 = ½ of the total slag made. No account is taken here of any CaO introduced by ores or taken up from the hearth or fettling materials. It does not affect the CaO requirements, but should be deducted from the quantity to be supplied if present in appreciable quantity.

Slag Analysis—Having ascertained the total make of slag, the SiO_2, P_2O_5, and MnO contents can now be stated in percentages, and its value as a fertilizer or otherwise determined.

The CaO contents have already been decided, and percentage allowances can usually be made for the inevitable Al_2O_3 and MgO within normal limits as per schedule; though under exceptional circumstances these items may need to be specially estimated. There remain only the iron oxides, FeO and Fe_2O_3, which, as a rule, may be taken by difference and will not be far off the mark. They may be considered together as FeO, and together with MnO constitute the basis in an acid slag; but in a basic slag they may be regarded simply as diluting the primary acids (SiO_2, P_2O_5) and bases (CaO and MgO) of the solution. Campbell, Harbord, and other authorities agree that FeO and MnO are together approximately a constant proportion in the slag, but as MnO is more liable to volatilization than FeO, it may, therefore, be less than as calculated—its place being taken by FeO. Hence, if there be much MnO present, the FeO contents will be relatively low, and vice versa, MnO displacing FeO within this proportion; but when for any reason the two are present in excess, it is at the expense of the chief constituents, and the slag calculation should be made again on an amended basis of acid and CaO contents accordingly. Similarly when the two together are less than normal, the slag will be found to contain higher percentages of acids and CaO than those on which these calculations are based. In this connection it should be remembered that if FeO is present in excess the carbon may be gone before tapping heat is reached, and the steel will be wild; while if deficient, the reactions will fall off and the carbon may "stick" until further ore additions are made—conditions which it is the steel-smelter's business to avoid.

Metallic Yield—An approximate metallic balance-sheet may now be drawn up, though some of the losses are more or less indeterminate and have to be assumed from known results in actual practice. On one side may be debited the metallic charge, Fe received from the oxides, and the ferro-alloys used in the ladle; and on the other the furnace may be credited with the metalloids oxidized, Fe carried off as oxide in the slag, sand allowance, metallic shot in the slag, scrap lost in the slag ladle, pit scrap, metal scrap, charging and teeming splash and spillage, metal volatilized, etc. A typical balance-sheet is as under:

Dr. Metallic charge	**100.00**	**Cr. Sand allowance**	**nil**
Fe from ores	**16.30**	**Metalloids oxidized**	**6.20**
Ferro alloys (say)	**0.70**	**Fe as oxide—in slag**	**1.76**
		Mechanical losses, volatilized and unaccounted for } estim'd	**4.00**
		Balance—ingots and scrap	**105.04**
Total	**117.00**	**Total**	**117.00**

To keep a reasonably accurate account over a period, a steelworks should in every department be kept as clean and free from scrap of all sorts as possible. Everything must be weighed in and out and complete analyses frequently taken and duly averaged together. Even then an exact account will always remain an impossibility. Such a balance-sheet can only be approximate; but it is none the less interesting and useful for making comparisons or for setting up a standard of efficiency. It indicates the various directions in which losses may occur and their relative importance. Particular attention should be paid to the mechanical losses—especially in the handling and transfer of molten steel or metal, and to all apparatus and machinery employed, with a view to minimizing the more or less inevitable waste and carelessness in this direction. It is most important that molten metal be handled as rarely and expeditiously as possible. There is usually far too much scrap and waste, metal skull, spillage, and pit scrap, etc., to be seen about a steel plant, all representing losses of yield—some recoverable, others final. The importance of these losses should be better appreciated and the fact realized that with ingots at, say, 75s per ton in normal times, each unit gained or lost represents a value of approximately 9d per ton.

As regards metallic shot and scrap lost in the slag where basic phosphate slag is made and ground for fertilizer, the bulk of it can be recovered, and the loss in this direction approximately ascertained. Otherwise, it can only be guessed at from a look over the tip; but even where facilities and supervision are good it is rarely less than 4 per cent of the slag made, or say 1.00 per cent of the metallic charge, and may be very much higher. A serious fault of the tilting furnace is the impossibility of running the slag off entirely without losing metal into the slag tub; for whenever the furnace is tilted the metal, being very much heavier than slag, finds its level and comes up first, whereas the slag remains lying on a perfectly level surface. Some loss of metals (Fe and Mn) by volatilization is inevitable, but it may be excessive—probably through too thin a covering of slag on the bath, or due to a needlessly high temperature. It is seen—oxidized—in the dense brown fume of the converter, and in the lighter brown smoke from the open-hearth furnace chimney; and is often found oxidized and condensed in the ports, flues, and checkers as a very light oxide—Fe_2O_3—exactly like purple ore in appearance (though not in weight), though purple ore may never have been used at all in that furnace. It is constantly found in the checkers of basic furnaces working the Martin process without a pound of ore being used.

The full calculated quantities of Fe introduced by the oxides may not actually be used in practice, as already noted, and the yield and balance-sheet will be affected accordingly. Provided that they are efficiently used, and not wasted, the higher the consumption the better from this point of view; for the Fe unit in the form of steel ingots is normally worth 9d., as against its cost in the form of ore at say 4d in normal times—a difference of 5d per ton of ingots.

Whatever the process, there will inevitably be such mechanical losses, some recoverable (though as scrap only) and others final; besides which some margin must be allowed for discrepancies and approximations within probable limits of accuracy. In order to compare results, it is necessary to adopt a reasonable figure as a standard for these "unaccountable" losses by each process; and from various data, checked by working back from known yields of various processes, the author arrives at the following figures, which are adopted throughout these calculations:

"Mechanical Losses," "Volatilized," and "Unaccounted"

	Per Cent	
1. By the acid Bessemer (direct metal) process	6.00	
2. By the basic Bessemer (direct metal) process	6.00	
3. By the basic open-hearth (direct metal) process	4.00	
4. By the basic open-hearth (cold pig iron and scrap)	3.00	
5. By the acid open-hearth (cold pig iron and scrap)	2.00	
6. In the acid Bess. preliminary processs	4.00	plus 4.00 further loss in the basic open-hearth finishing furnace.
7. In the basic Bess. preliminary process	4.00	
8. In the basic open-hearth (mixer) preliminary process	2.00	

N. B.—All these losses are per ton of the charged weight—not per ton of product, to give which they must be divided by the yield realized.

Sulphur in the Basic Process.

The elimination of sulphur in the basic process is a fairly simple matter, and a much higher limit of sulphur in the pig iron is therefore permissible than in the acid process. It will usually fall to something less than 0.10 per cent at a low temperature in the mixer or in melting, without assistance, provided the metal contains sufficient manganese; and it falls further, as the process proceeds down to 0.08 per cent or 0.06 per cent. Such difficulty as occurs is not in reducing it to this level, but in removing the next few points, when required; yet the ancient prejudice that basic steel requires to be lower in sulphur than acid steel in order to be equally good still lingers—this notion apparently arising from the fact that basic steel usually is lower, and is in that respect a better material. When especially low sulphur steels are required—under 0.05 per cent sulphur—they can be made without much difficulty other than reduced output—which must be accepted. The conditions for its removal in the furnace are: (1) a more basic slag, and (2) a higher temperature, or, in the language of the furnacemen, "a thick slag and a strong boil." Sulphur is slow to move (but does not "go back" like phosphorus), and the slag should be rather "thick" from the beginning in order to insure its removal by the time the carbon reaches the desired point. The tendency of both these conditions is to reduce the percentage of acids in the finishing slag, or, in other words, to increase the make of slag at the expense of output of steel. Its CaO contents may rise to 56 per cent or more, and the total acids fall to 18 per cent or less—indicating some 50 per cent increase in slag make. For instance, if from 100 tons charged, the total acids amount to 5.40 tons, the make of normal slag containing, say, 27 per cent of acids is $5.40 \div 0.27 = 20$ tons; whereas the make of an abnormal slag containing only 18 per cent total acids will be $5.40 \div 0.18 = 30$ tons—an increase of 50 per cent in slag production. The lime consumption is still further increased, for instead of being one-half the slag make as usual, it becomes $56 \div 96 \times 30 = 17.5$ tons—an increase of 75 per cent. The percentage of P_2O_5 is also reduced to two-thirds of what it should be, and the effect on output of steel and costs generally is serious. One need hardly urge the necessity of avoiding such practice without very good reasons—and extras. Unfortunately, in the blast-furnace, silicon and sulphur move in opposite directions—sulphur decreasing with higher silicons, and vice versa. Choice may be made and limits specified for either, but not both, and the usual practice is to compromise by aiming at 1.00 per cent silicon with 0.10 per cent sulphur—which leaves a working margin either way to both blast furnaces and steelworks. Phosphorus is rarely mentioned in basic iron specifications!

It is frequently observed that when a furnace has been delayed for any reason, and the slag undesignedly has got into the above condition, the sulphur contents of the steel are unexpectedly and unusually low without any attempt to make them so.

Pig Irons—For the purpose of calculation and comparison of the various processes, typical pig irons have been selected as under and are taken as standards throughout these calculations.

	C.	Si.	P.	Mn.	
1. Hematite—mixed Nos.	3.80	2.50	0.06	1.00	Natural hematite iron
2. Hematite—special	3.20	1.00	0.06	0.80	Special hematite (American "Bessemer")
3. Common forge	3.50	1.80	1.50	0.60	Natural iron (Cleveland, Northants)
4. Common basic	3.20	1.00	1.25	1.20	Low silicon iron with proportion of foreign ores
3. "Thomas" special	3.20	0.50	2.25	2.20	Continental — high phosphorus and manganese

An appropriate iron has been selected for detailed calculation by each process as under and the results, together with those of other possible irons, are tabulated for comparison:

Hot Metal Processes.

1. Bessemer acid process with direct molten iron—hematite (mixed Nos.)

2. Bessemer basic process with direct molten iron—"Thomas."

3. Open hearth basic process with direct molten iron—common forge.

Scrap and Cold Pig Processes.

4. Open hearth acid process with 50 per cent scrap, 50 per cent pig—hematite (mixed Nos.).

5. Open hearth basic process with 50 per cent scrap, 50 per cent scrap, 50 per cent pig—common forge.

6. Open hearth "Martin" process with 75 per cent scrap, 25 per cent pig—common basic.

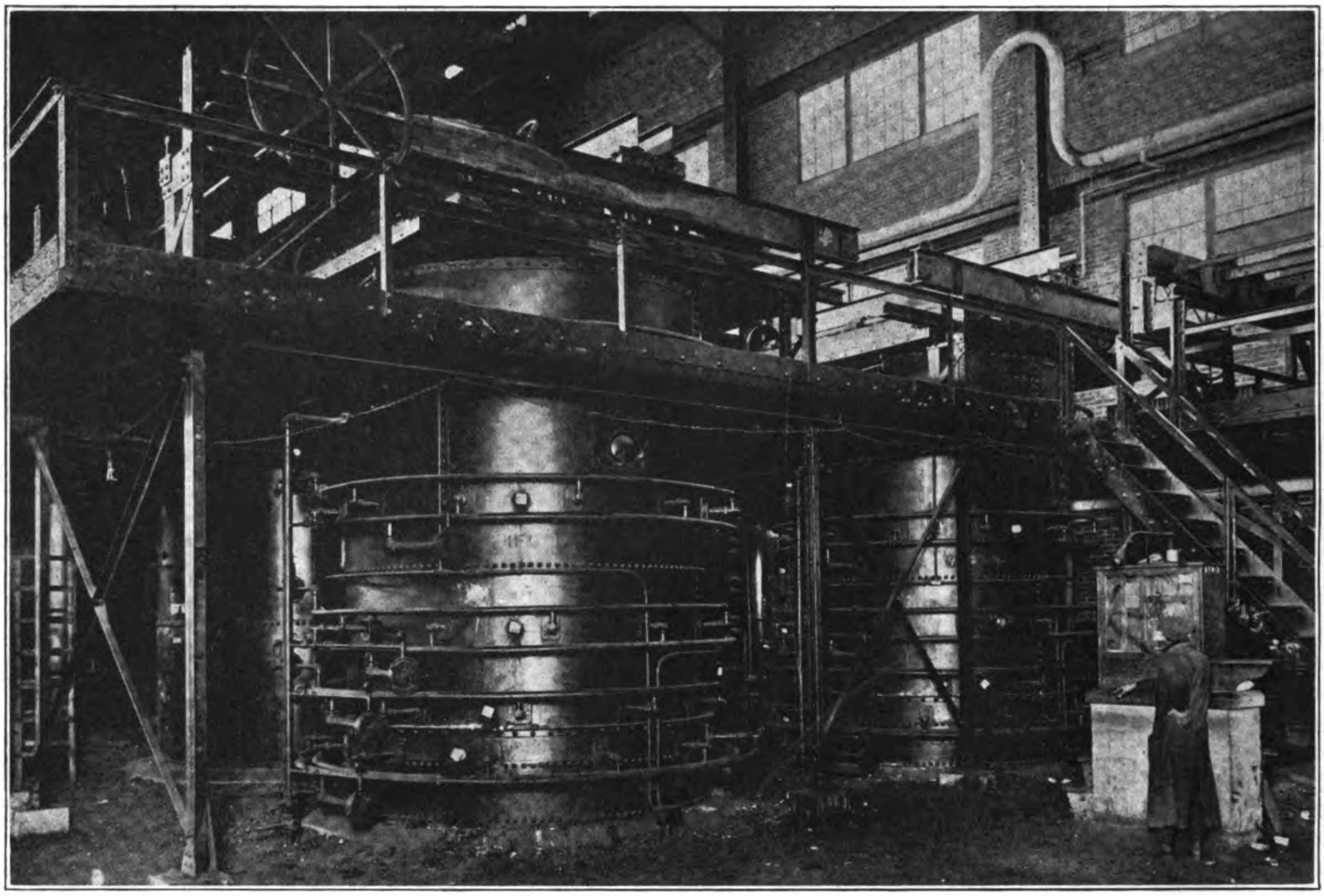
Duplex Processes.

7. Acid Bessemer and basic open hearth, with direct molten metal—common forge.

8. Basic open hearth (mixer) and basic open hearth, with direct molten metal—common forge.

9. Basic Bessemer and basic open hearth, with direct molten metal—common forge.

The above processes will be dealt with in future installments of this series.



Furnace used during the war for the heat treatment of gun tubes and heavy artillery parts at the United States government arsenal, Watertown, Mass.

Heat Treating Furnaces for Heavy Artillery

Vertical Steel Shell Type Furnace—Burners Connected to Manifold Provided With Special Proportioning Inspirator for Operation on High Pressure Gas—Comparative Cost Data.

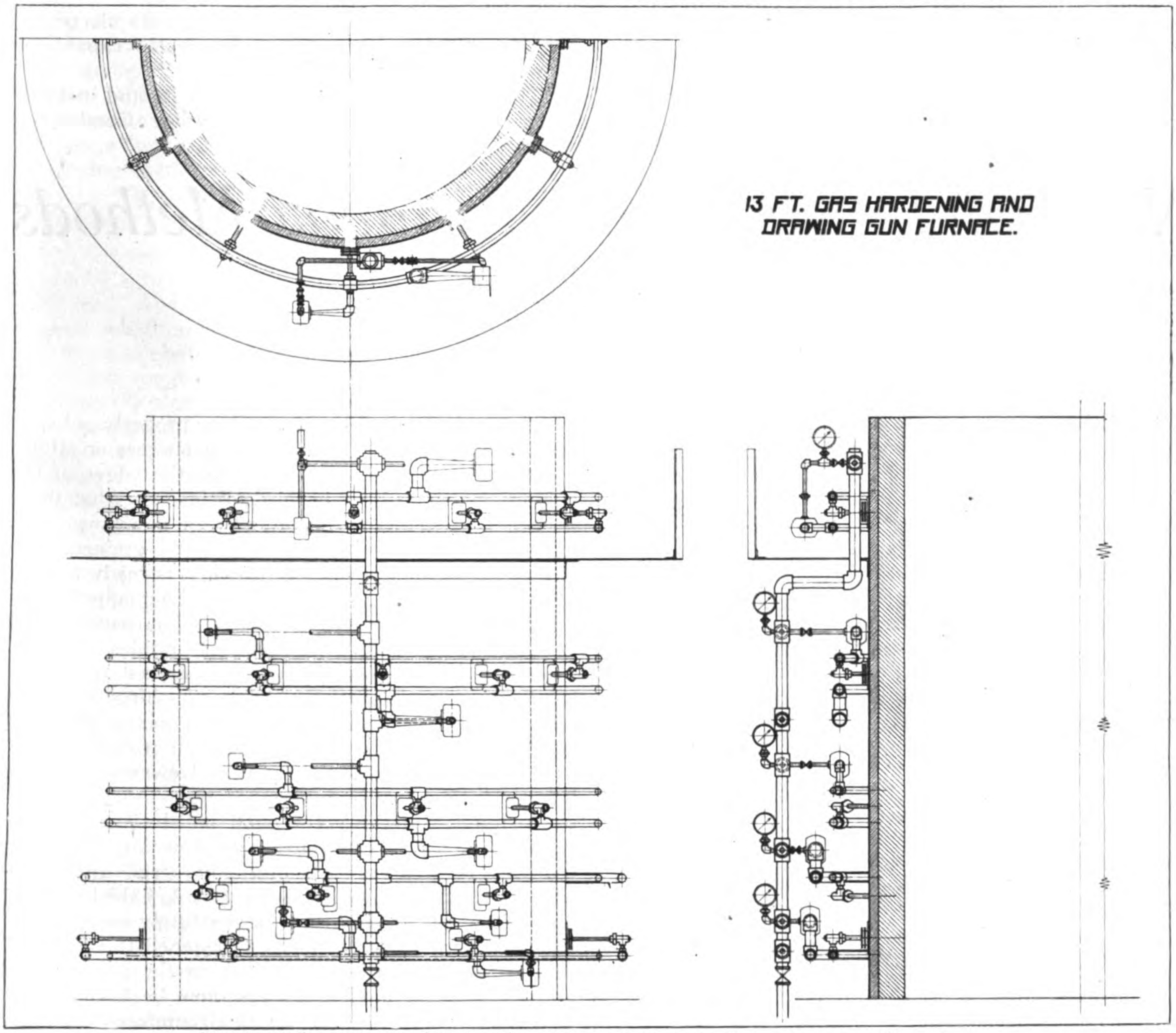
By **WILLIAM J. HARRIS, JR.**
Engineering Department, Surface Combustion Company.

Munition manufacturing is fortunately becoming very rapidly a thing of the past for most of us, but the government arsenals will no doubt continue in operation for many years to come. Moreover there are many peace time processes which can make advantageous use of war time ideas. The furnaces about to be described come well within the latter classification. They were installed at the United States government arsenal at Watertown, Mass., for the heat treatment of gun tubes and other parts of heavy field artillery.

The general design of each furnace comprises a vertical steel shell lined with firebrick and suitable insulating material, and provided with a sliding cover. The work to be heated is suspended in the furnace by means of a hanger passing through a comparatively small hole in the cover. The general mechanical features, such as cover design, method of handling the work, etc., were well worked out by the Ordnance Department engineers from their previous experience at other plants, but the use of standard "city" or illuminating gas as fuel, and the burner equipment which made its use possible was an entirely novel feature. Heretofore furnaces used for this work have been exclusively oil fired and have necessarily been constructed with an inner baffle wall running the full height of the inside to protect the work from the direct flame of the oil burners and consequent danger of local overheating or burning of the steel. The baffle wall which may be a pure muffle or merely a checker brick screen, is subject to frequent repairs, and is liable to injury while handling the work in or out of the furnace.

The location and arrangement of the gas burner equipment is shown by the accompanying drawings and photographs. The burners are placed in tiers with two sets of six burners to each tier. Each set of six burners is connected to a manifold which is provided with a Surface Combustion proportioning inspirator for operation on high pressure gas. A motor driven compressor of the rotary hydro-turbine type is used for compressing the gas to approximately 10 pounds per square inch. No air blower or air piping is used, as the inspirators induce the required amount of air from the surrounding atmosphere and supply the burners with a homogeneous and correctly proportioned mixture at all times. On each inspirator a small globe valve is used to control the gas and a spring pressure gauge indicates the adjustment.

The automatic proportioning and homogeneity of the air gas mixture insures rapid and complete combustion very close to the burner orifice, and this in turn means that the work will be surrounded by a furnace atmosphere free from uncombined oxygen, a condition which is required for minimum scale formation. The burner orifices are arranged tangentially to the inner face of the furnace lining. Consequently, the gases have a circular motion with a very high velocity. There is practically no visible flame anywhere in the furnace and the walls have such a uniform color that it is hard to believe they are not the inside of a muffle instead of the furnace lining.



Sketch of furnace showing location and arrangement of gas burner equipment.

The automatic proportioning feature in conjunction with the pressure gauges also makes possible a very accurate temperature control. The gauge indicates the pressure on the gas orifice in the inspirator and hence the amount of gas passing through it. As the air supply is automatic, the pressure thus becomes an indication of the heating effect which will be obtained and a very accurate means of adjusting the furnace temperature. The tiers of burners are spaced closer together at the bottom of the furnace than at the top in order to counteract the natural tendency of the hot gases to rise and cause overheating at the top. The reason for using two sets of burners in each tier is to make it possible to use the same furnace for both hardening and drawing temperatures; one set of burners being larger than the other. The temperature control has proved exceedingly satisfactory as it has been found that the difference between top and bottom of the 37 ft. furnace does not exceed 5 degrees C. (9 degrees F.). This is as close as the pyrometers can be read and is true for both hardening at about 900 degrees C. (1,652 degrees F.) and drawing at about 620 degrees C. (1,148 degrees F.).

The complete installation consists of two gas fired furnaces 13 ft. high and one 37 ft. high, and two electric furnaces 13 ft. high and two 27 ft. high. All have an internal diameter of 7½ ft. The temperature control of the electric furnaces is equal to that of the gas, but the resistance ribbon does not seem to stand up well at the hardening temperature. Both installation and operating costs have proved much greater than gas.

The following table shows the comparative operating costs for gas and electricity:

To harden one ton (2,000 lbs.) steel cost $6.00 for electricity
To harden one ton (2,000 lbs.) steel cost 4.40 for gas
To draw one ton (2,000 lbs.) steel cost 4.25 for electricity
Rate for electric current = $.0085 per kw hr.
Rate for 530 Btu gas = .55 per 1,000 cu. ft.

Supports for work weighed the same for both electricity and gas, and therefore, need not be considered in the comparison. Cost of labor is the same for either.

The cost of gas for drawing is not known because the gas furnaces are seldom used for this work. The reason for this is that as mentioned above, the electric equipment does not stand up well at the higher temperatures and as a result practically all the hardening is done with gas, and the drawing with electricity, although the gas furnaces are perfectly capable of drawing and are sometimes so used.

The gas equipment was furnished by and installed under the supervision of the Surface Combustion Company of New York City.

Notes On Practical Metallographic Methods

Methods of Polishing and Etching Which Are Giving Satisfactory Results—Description Applies Only to Steel Specimens. Illustrations Show Results Attained.

By **AUSTIN B. WILSON.**

Much has been written on the subject of metallography in this and other countries. The structures met with in both ferrous and non-ferrous alloys have been exhaustively discussed although there is much still to be learned concerning them. Nevertheless the writer has never seen published in such form as to be easily followed a description of the methods employed to develop the microstructure of alloys and although something has been written on this subject it has always been more or less indefinite.

This the writer will attempt to do. The following paragraphs will describe and explain methods of polishing, etching, etc., which are giving satisfactory results in everyday work. These methods are rapid enough for routine work and, used with a little care, sufficiently accurate for research work of the most advanced character. The methods of preparing steel specimens only will be described in this article. Where it is thought advisable illustrations will be given to show the results obtained.

The selection of the spot from which the specimen is to be cut is very important. This will depend almost entirely upon the character of the piece to be examined. If the material is rolled or drawn stock, it is customary to prepare a plane parallel to the direction of rolling, as some impurities are more readily recognizable in a longitudinal section. If a casting almost any average part will do. If the material has failed in service or in an unwarranted manner, it is usual to cut a section either through or near the fracture. A fresh cut surface should always be preferred as it has been less exposed to the carburizing or decarburizing action always more or less present in outside surfaces. These, however, are only generalities and each case must be considered separately.

The surface selected must now be properly polished and upon this polishing depends the success or failure of the succeeding operations. First the edges of the side to be polished are beveled off in order that there may be no sharp edges to catch in the polishing cloth. The surface is then ground flat on a fine-grained, cup-shaped alundum wheel, after which it is ready for the polishing proper. This is conducted on a polishing table of the type shown in Fig. 1. The papers used in order are French Hubert papers grades 2 to 00. These or similar papers may be obtained from any laboratory supply house. After polishing on each paper the specimen is rotated 90 degrees so that the scratches from each grade of paper run at right angles to those of the preceding paper and eventually erase them. It is necessary that all scratches from the paper immediately preceding be polished out before transferring to the next paper as it is impossible to remove them later. A convenient sized specimen which is easily held is ⅝″ square by ¼″ thick. Flatness of the polished surface is absolutely essential to good polishing. The papers are fastened to the small disks shown in Fig. 1. In polishing the best results are obtained by moving the specimen back and forth in a straight line from center to circumference of the revolving disk although it is not wise to move them quite to the outer edge as this has a tendency to round off the corners. If the dry polishing has been conducted properly the specimemn now contains only scratches from the 00 paper all running in one direction. It is now ready for the wet polishing.

The specimen is now polished with alundum suspended in water, the scratches from which must erase the scratches from the last paper. If, however, this polishing is carried too far the specimen will become pitted after which no amount of polishing will give a satisfactory surface. If, therefore, the operator notices the surface pitting, it is best to discontinue the polishing with alundum at once even if the fine scratches from the paper are not entirely eliminated as they will be more easily removed with rouge than would very deep pits. The specimen must now be dried at once to prevent rusting and for this purpose a chamois cloth is kept at hand. The disk for this polishing is covered with a duck cloth and the alundum is squirted just in front of the specimen at intervals of a few seconds from a wash-bottle. The alundum used is No. 65 F and can be secured from the Norton Company, Worcester, Mass., in one pound cans. It is prepared by placing about one teaspoonful in 250 cc of distilled water, stirring well and after allowing to stand for one minute pouring off that still in suspension. The grains which are coarse enough to cause really deep scratches settle readily within that time and are discarded. The specimen is now ready for the final polishing.

The final and only true polishing is done on a disk covered with a fine grade of broadcloth with the nap side up. The cloth is kept wet by a stream of red rouge which is allowed to fall continually upon it from a wash bottle. Red not black rouge must be used as black rouge has an undesirable tendency toward etching the steel. In this operation the specimen must not be moved back and forth from center to circumference as on the other wheels but it must be kept moving in such a manner that the direction of the polishing wheel in relation to the specimen is constantly changing. The most convenient way to accompish this is to move the specimen around the circumference in the direction opposite to which the wheel is traveling until the coarser scratches are removed and then closer to the center for the finishing touches. To obtain first class results uniform pressure must be maintained on all parts of the specimen during polishing. The amount of rouge to be used can only be judged by experience but as a rule the thicker the rouge which can be used without scratching or pitting, the better. Ordinary fine red rouge such as is used by jewelers is sufficiently fine for the highest grade work if the following method of preparing is followed. The rouge is placed to a depth of about 2½ inches on the bottom of an ordinary flat back bottle of about one quart capacity. The bottle is then filled with distilled water to within about one inch of the neck, after which it is shaken vigorously until the rouge and water are thoroughly mixed. It is then allowed to stand over night. The next day the bottle is shaken gently until the water becomes clouded with rouge. The water with rouge in suspension is now ready for use and is poured off into a wash bottle. The storage bottle is again filled with water, shaken vigorously as before and the rouge allowed to settle before again drawing off more. A bottle of rouge thus prepared will furnish rouge for a great number of samples. The long and troublesome methods described in some textbooks for preparing rouge are not necessary as is shown by the author's photomicrographs all of which were prepared as described in this article.

Contrary to the statements of many writers it is impossible to obtain surfaces free from scratches except in the case of very hard materials. The object of polishing is not to obtain a surface free from scratches but to obtain the best possible surface for microscopic investigation. A low carbon steel, for instance, may be comparatively free from scratches and at the same time entirely unsuitable for microscopic work, due to a brown stain which frequently occurs in this class of steel. This stain prevents proper etching. In this case the object is to avoid the stain and reduce the scratches always present to a minimum or at least until they do not interfere with examination. The best manner in which to polish each class of material can be readily judged after a little experience but care in polishing must always be exercised.

The operations of polishing having been described, a description of the polishing table would not be amiss. Figure 1 is a photograph of the table used in this laboratory and is without doubt the best of its kind on the market. This type of table is called a Zimmerschied polishing table after the designer, and can readily be secured from the engineering school of the University of Michigan. The motive power is furnished by a small motor placed overhead and not shown in the picture. There are spindles for four disks which can be operated independently of each other, one of the four controlling levers being shown in the picture. The disks are friction drive and the speed of each can be varied independently of the rest, in this case the speed of the rouge wheel being 750-800 rpm and that of the other wheels being 400-450 rpm. The disks are interchangeable which is a great convenience as it is not necessary to remove the papers from the disks as the specimen progresses from one grade to the next. Simply lift off the disk and replace it with the one desired. The paper is merely tied on the disk with string and is easily changed when worn. As shown the disks with paper attached are kept when not in use in a case provided for this purpose but not supplied with the table. Both the alundum and rouge wheels are kept covered when idle with bell jars as shown to protect them from dust, etc. The disk cases at the far side of the table are used for the disks carrying papers. The two on the near side are reserved for the wet polishing; the one on the left for the alundum and that on the right for the rouge. The disks are made of bronze to prevent rusting. Next to the alundum wheel is a wash-bottle containing alundum prepared as above. The wash-bottle above the rouge wheel contains the rouge. This bottle is arranged so that by means of the long tube shown the water with the rouge in suspension is allowed to syphon off, the rate at which the rouge drips upon the wheel being regulated by means of the screw valve just above the tube. A small rack directs the stream to any part of the wheel as desired. The bottle must be shaken frequently to keep the water and rouge thoroughly mixed as the rouge gradually sinks to the bottom. On top of the cabinet is the rouge storage bottle. The large bottle at the right contains distilled water for washing off specimens after etching, etc. Underneath the top of the table runs an inclined trough to which tubes lead from each polishing wheel to carry off the waste

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alundum and rouge. This trough empties into a pail as shown. The table is strong and well-built and will give good service, the one in the picture having now been in use for seven years.

After the final polishing with rouge the specimen is ready for microscopic examination. It is customary to examine the specimen for non-metallic inclusions before etching. The non-metallic inclusions in ordinary steel are slag or silicate, sulphides (of Mn or Fe), alumina, iron oxide and titanium nitride. Typical examples of these inclusions are shown in Figs. 2 to 5. Silicates are readily distinguished from other inclusions being a very dark color, elongated in the direction of rolling and capable of taking a very smooth polish. Alumina particles are present in steel as small rounded spots of a bluish-gray color, not elongated, and which are almost impossible to polish without forming pits in the metal around each inclusion. At a low magnification they appear black but when highly magnified they are seen to be particles of a bluish-gray substance the black ring being due to the pitting of the metal just described. It is impossible to confuse titanium nitride with any other inclusions found as titanium nitride crystals have an angular form with pink or orange colored centers unlike any other inclusions present in steel. In order to distinguish these inclusions it may be necessary to use a magnification of 400 diameters although 200 is usually sufficient. Sulphides are readily distinguishable by their smooth dove-gray appearance known to all metallographists. Oxide of iron is a slightly darker gray than manganese sulphide. It is is not easy to distinguish between these two without long experience and even then it is not always possible. The difference between these two kinds of inclusions can however be readily shown by etching with alkaline sodium picrate which blackens the sulphide inclusions without attacking the oxides. Figures 5 and 6 illustrate a typical case of the results obtained by the use of this reagent. Fig. 5 shows sulphide and oxide inclusions indistinguishable in an unetched section all the inclusions being the same gray color. Fig. 6 shows the same view after etching with this reagent. The oxides are seen to be unattacked while the sulphides are now black. This reagent furnishes a simple and effective method for distinguishing between oxides and sulphides. The manner of preparing and using is described below in connection with the etching of cementite in high carbon steel.

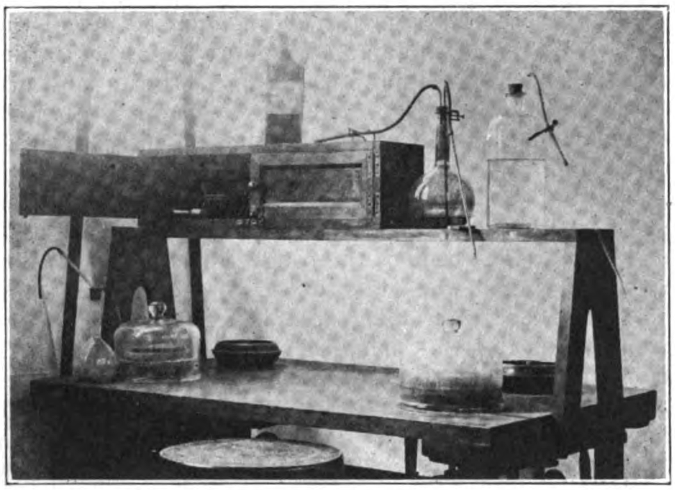

Fig. 1—Zimmerschied polishing table.

After completing the examination of the unetched specimen it must be etched to develop the microstructure. The selection of the proper etching reagent and its correct use require considerable experience and skill. The most important reagents in the metallography of steel are picric acid, nitric acid, cupric chloride and alkaline sodium picrate. These reagents are prepared in a variety of ways and each has some particular use for which it is best suited. Considerable experience is necessary to know just how far to allow the etching to proceed, which can only be acquired by practice. There are, however, a few general considerations to be observed which can be mentioned here. If the etching be carried too far, i.e., the specimen be etched too deeply, the surface is roughened and pitted and is unsuitable for microscopic examination as the contrast between the different constituents has been destroyed or at least greatly diminished. In this case the only remedy is repolishing which can usually be accomplished with the rouge. It is therefore better to under-etch than to over-etch as in this case it is merely necessary to re-etch the specimen, without re-polishing, until the desired degree of etching has been attained. After etching and in fact after the final polishing the specimen should be kept in a dessicator to prevent rusting which takes place rapidly on a highly polished surface.

Picric acid and nitric acid produce almost the same effect when used to etch steels. They both darken pearlite and leave ferrite and cementite unattacked unless the etching is carried too far when the ferrite will become stained. There are, however, instances in which it is better to use nitric acid than picric and vice versa.

Low carbon steel consists of ferrite with some pearlite between the grains. In etching this class of steel it is desirable to darken the pearlite and to develop the grain boundaries and at the same time to leave the ferrite grains as unattacked as possible. For this purpose the best etching solution is 5 cc of nitric acid and 95 cc of 95 per cent ethyl alcohol. The specimen, held by a pair of tongs, is immersed for a few seconds, until etched sufficiently in this solution contained in a small glass dish. While immersed the specimen is shaken rapidly back and forth to insure uniformity of etching. It is then rinsed off in running water and dried by squirting a little absolute alcohol on the surface with a medicine dropper and wiping the surface with a soft cloth. If the foregoing method has been followed the result will be similar to that shown in Fig. 8 which is typical of the structure developed. Picric acid in either 95 per cent, or absolute alcohol, or nitric acid in absolute alcohol, will darken the pearlite but will not develop the grain boundaries as well as the above reagent. Why this is the writer does not know but the fact remains.

For medium and high carbon steels a 5 per cent solution of picric acid in absolute alcohol gives the

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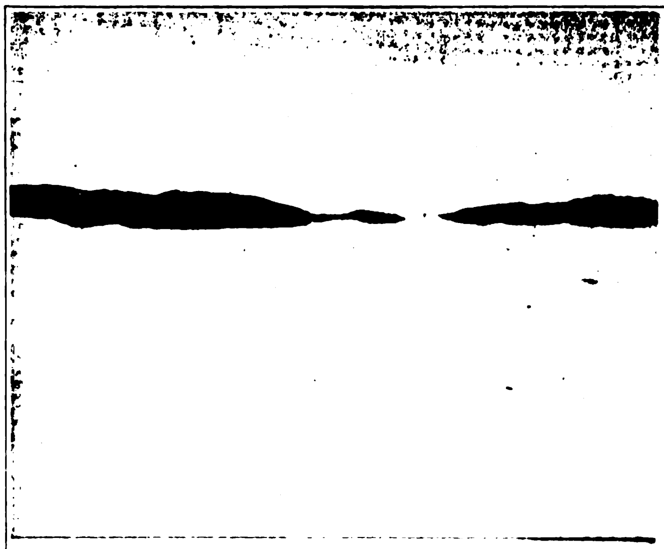

FIG. 2

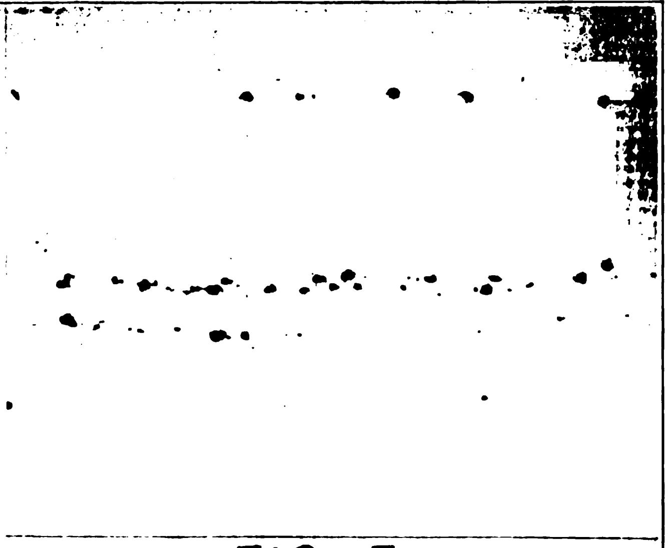

FIG. 3

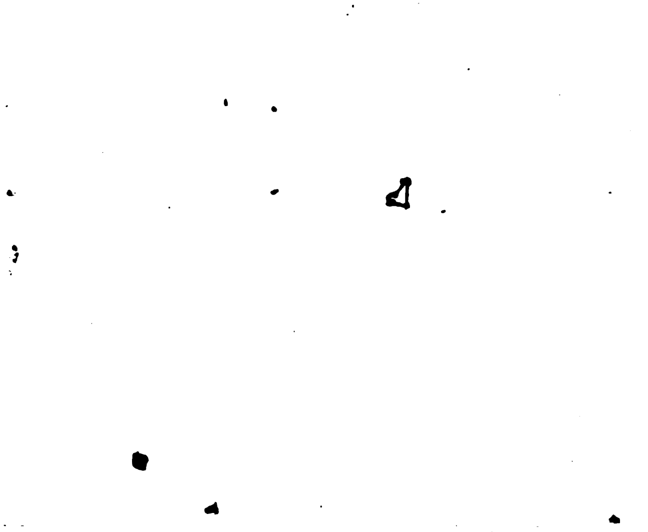

FIG. 4

FIG. 5

FIG. 6

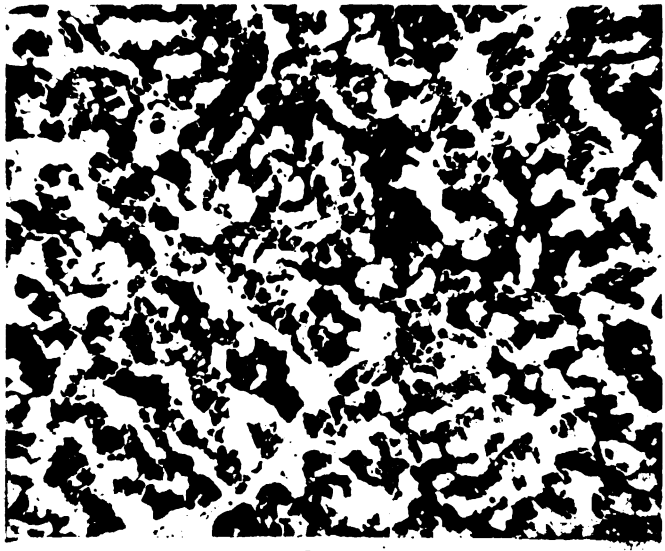

FIG. 7

Fig. 2—Large slag streak in steel, unetched and magnified 200 diameters. Fig. 3—Typical streaks of alumina in unetched section. X 200 diameters. Fig. 4—Typical angular crystal of titanum nitride in unetched section. X 200 diameters. Fig. 5—Typical oxides and sulphides in unetched section. X 200 diameters. Oxides and sulphides appearing almost identical. Fig. 6—Same view as Fig. 5 after etching for 10 minutes in boiling alkaline sodium picrate. Oxides unattacked but sulphides are blackened. Fig. 7—Typical structure of cast medium carbon steel after annealing etched with picric acid. X 50 diameters.

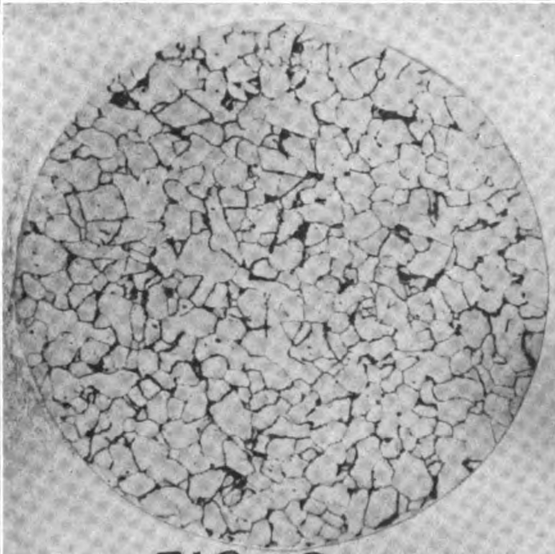

FIG. 8

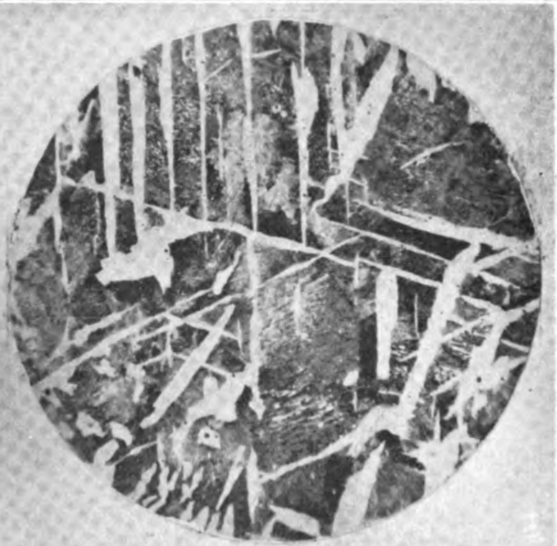

FIG. 9.

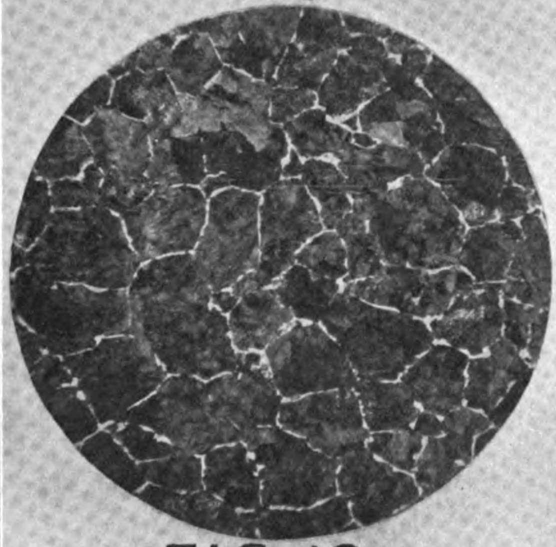

FIG. 10

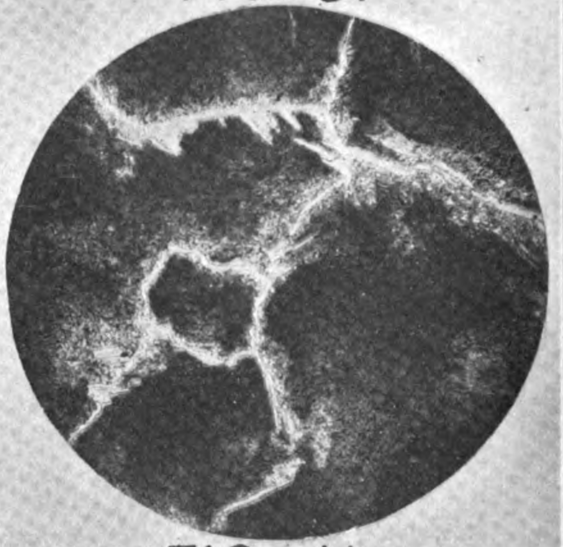

FIG. 11

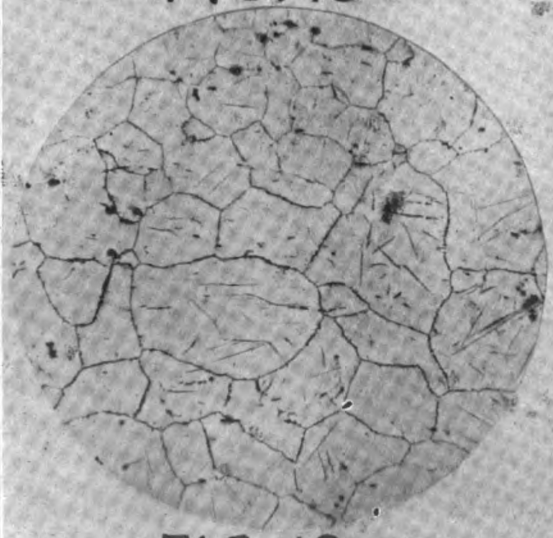

FIG. 12

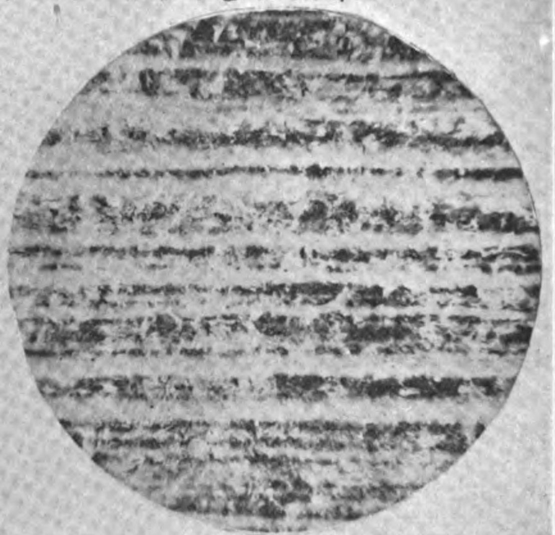

FIG. 13

Fig. 8—Typical structure of low carbon steel etched with nitric acid as described. X 100 diameters. Fig. 9—Typical cast structure of medium carbon steel (rather coarse grained) etched with picric acid. X 100 diameters. Fig. 10—Typical structure of rail steel etched with picric acid. Ferrite and pearlite. X 100 diameters. Fig. 11—Pearlite with thick intergranular layers of cementite, etched with picric acid. X 100 diameters. Fig. 12—Pearlite and cementite. Cementite darkened by etching with boiling alkaline sodium picrate as described. X 100 diameters. Fig. 13—Typical structure produced in rolled or forged steel by etching with cupric ammonium chloride. X 20 diameters.

best results. This solution has two distinct advantages for this class of work. It works more slowly so that greater control may be exercised and it develops the lamellae of the pearlite more distinctly than does any other reagent. It is prepared by dissolving 5 grams of anhydrous picric acid crystals in 95 cc of absolute alcohol. As the acid dissolves very slowly it is best to place the crystals in a glass stoppered bottle, add the alcohol and shake well. It will be necessary to shake many times before the crystals are completely dissolved. This reagent is applied to the specimen, which is held on a small watch glass, by means of a medicine dropper. The watch glass is continually tipped in such manner as to keep the solution circulating over the surface of the specimen. If this is not done the specimen will not be uniformly etched, the center remaining unattacked. The picric acid will gradually become discolored during the etching and as this occurs it may be necessary to add a few more drops of the reagent from time to time until the degree of etching desired has been reached. When the structure has developed sufficiently the specimen is thoroughly rinsed off with water and then washed several times with absolute alcohol from a medicine dropper after which it is dried by waving in the air. The surface must not be wiped off. Figures 7, 9, 10 and 11 are typical of results obtained by this method. Fig. 14 shows lamellar pearlite which is composed of alternate lamellae of ferrite and cementite. The dark lines shown are not due to the darkening of either of the constituents but to the sloping boundaries of the lamellae caused by the cementite standing out in relief, which reflect the light outside the microscope. The practiced eye can readily distinguish the difference between ferrite and cementite after etching with picric acid although the inexperienced eye would see little difference. Fig. 10 shows ferrite and pearlite. It will be noted that the ferrite does not show any definite boundary separating it from the pearlite. On comparing this with Fig. 11 showing cementite and pearlite the difference will at once be apparent. Although the cementite is itself unattacked fine dark lines are seen around its edge where it touches the dark pearlite grains. This also is due to the cause above mentioned.

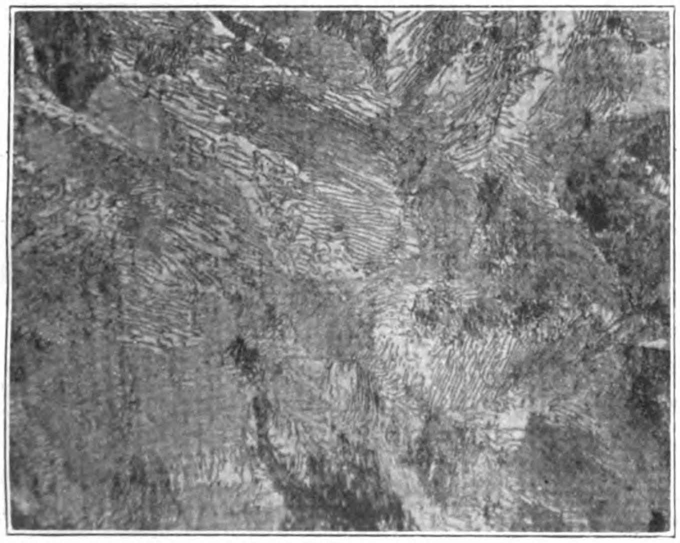

Fig. 14—Typical lamellar pearlite developed by etching with picric acid. X 400 diameters.

Alkaline sodium picrate was first discovered by Kourbatoff who recommended it for darkening cementite because it does not attack ferrite or pearlite. It was later used by Comstock to distinguish between oxides and sulphides as described above. Fig. 11 is an illustration of a high carbon steel etched with alkaline sodium picrate. The cementite is darkened as shown while the pearlite is unappreciably attacked. In preparing this reagent 25 grams of NaOH are dissolved in 60 to 70 cc of water, 2 grams of picric acid are added and the solution is heated until the picric acid is dissolved, when the volume is brought up to 100 cc by adding more water. In etching the solution is brought up to boiling, the specimen is then immersed in the solution and the boiling continued for 10 minutes. The specimen is then removed, washed and dried with absolute alcohol. The surface may be dried with chamois skin if preferred. It is possible to use this solution many times but as some of it evaporates in boiling, water should be added occasionally to keep the volume at 100 cc. The most reliable means of distinguishing between sulphides and oxides and between ferrite and cementite is afforded by the use of this reagent.

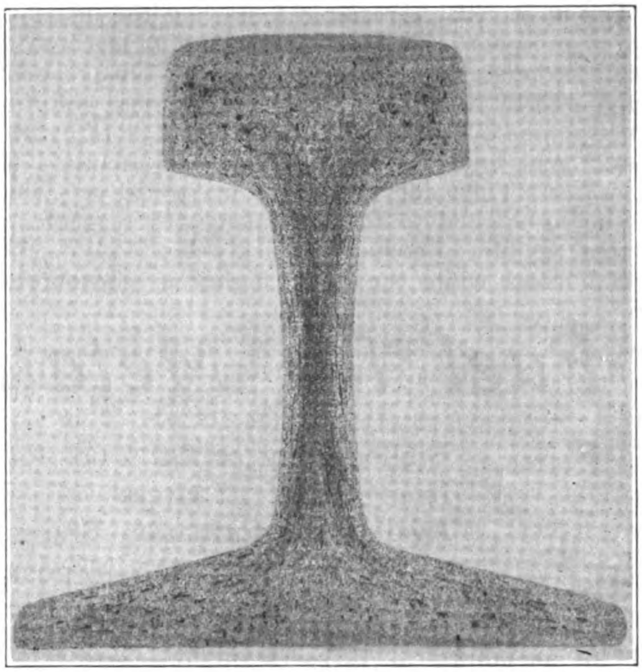

Fig. 15—Sulphur print of cross-section of rail showing segregation in web.

A sulphur print is the surest and quickest means of getting a picture showing the distribution of sulphur in sections and as usually the other elements in steel segregate in the same spots as does the sulphur, a sulphur print shows very well the distribution of all the elements present. Although well known, the method of making these prints will be described. The section need only be polished with coarse emery cloth but it must be perfectly clean.

A piece of any photographic "developing out" paper is well moistened in 3 per cent sulphuric acid. It is then placed on the piece of steel carefully so that a good contact is made at all points. Care must be taken that the paper does not slip after once touching the steel or a blurred print will result. Contact should be made for about one minute on the first print. The acid reacts with the sulphides liberating hydrogen sulphide which in turn reacts with the silver in the paper forming silver sulphide causing a dark spot above each sulphide inclusion. The print is then fixed and washed in the usual manner. A second and third print can be made by exposing to the acid for longer periods but for more than that number the section will probably have to be polished again. A good sulphur print is as well defined as a photograph of an etched section and is certainly less trouble to make.

The most reliable results in showing the distribution of phosphorus in steel have been obtained by the use of Stead's cupric chloride reagent. This reagent is prepared by dissolving 2.5 grams of cupric chloride and 10 grams of magnesium chloride in 5 cc of hydrochloric acid and the smallest possible quantity of hot water. Then add alcohol to make 250 cc. The solution is applied to the specimen with a medicine dropper. A film of copper is quickly deposited on the normal metal while the metal higher in phosphorus remains bright for a longer time. If this deposition of copper is not allowed to continue too long, the location of the high phosphorus spots will be shown very clearly as bright spots on a darker background. Copper, chromium, nickel and silicon and other elements forming solid solutions in steel produce a similar effect when exposed to etching with this reagent but the effect of phosphorus is the most important and is most commonly encountered. Fig. 13 is an example of this etching. More contrast, if desired, may be given to a specimen thus etched by dissolving off the deposited copper with ammonia. This is done by immersing the specimen in a small dish containing ammonia and then washing and drying in the usual manner.

Other methods of developing the microstructure of steel than those described in this article have been and are being successfully used. Methods such as heat-tinting, polish attack, relief polishing, etc., have their particular adaptations but it is the writer's belief that the above methods and reagents are adequate for all purposes in the ordinary investigation of steel. No attempt has been made to describe the heat-treatment which produces the different structures shown above as this is entirely beyond the scope of this paper and as it has been assumed that the reader is at least slightly familiar with the metallography of iron and steel, this was not thought necessary.

Fuel for Metallurgical Furnaces

Bibliography of Oil Fuel for Metallurgical Furnaces Compiled from Chief Sources of Technical Literature—Review of Available Information Shows Increasing Interest in Oil Fuel.

By ROSE DEMOREST.

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Fuel Oil Burner. 1918. (In Metallurgical and Chemical Engineering, v. 18, p. 146.) Describes a Coleman burner.

HERRICK, R. L.—Oil-fired reverberatory furnace. 1910. (In Mines and Minerals, v. 30, pp. 367-368.) *The same, abstract.* 1910. (In Journal of the Institute of Metals, v. 3, p. 258.) In general the use of oil for reverberatory firing is much cleaner, more economical and more efficient than coal. A detailed drawing of the Kittle oil burner is given.

IRINYI, A.—Physico-chemical processes in the vaporization of fuel oil with special reference to the use of oil burners in foundries. 1915. (In Chemical Abstracts, v. 9, p. 1111.) Abstracted from *Petroleum*, v. 10, pp. 9-14. 1914. The advantages of oil burning in the industries are offset by the high price of fuel oil and inefficient methods of oil combustion.

JANSSEN, W. A.—New method of burning crude oil. 1918. (In Transactions of the American Foundrymen's Association, v. 26, pp. 455-459.) Discussion, pp. 459-460. *The same, abstract.* 1918. (In Journal of the Iron and Steel Institute, v. 97, pp. 500-501. Describes and illustrates with drawings, a new burner, mixer and vaporizer that readily lends itself to every type of furnace.

Low pressure oil burner. 1915. (In American Machinist, v. 42, p. 260.) Contains a diagram.

Oil burner for foundry use. 1918. (In Foundry, v. 46, p. 91.) A burner that claims to be unique in the manner in which the oil is atomized and mixed with air.

Oil burner for metal heating furnaces. 1917. (In Mechanical Engineer, v. 39, p. 135.) *The same, abstract.* 1917. (In Journal of the Iron and Steel Institute, v. 94, p. 379-380.) A design of oil burner for use in conjunction with furnaces for the heat treatment of metals. Shows a sectional view.

Portable tank and oil burner. 1915. (In American Machinist, v. 43, p. 1041.) Describes an outfit that would be useful in a shop where local heating is to be done.

REDDY, B. H.—Operation of small open hearth furnaces. Various types of fuel oil burners are described with the arrangement of the burner port. How a small furnace was rebuilt. 1912. (In Foundry, v. 40, pp. 112-116.)

SCHEIL, K.—Ueber Kupolöfen fur Oelfeuerung. 1908. (In Stahl und Eisen, v. 28, pp. 1215-1220.) *The same, abstract translation.* 1908. (n Chemical Abstracts, v. 2, p. 3049.) The paper contains descriptions of a large number of burners.

SHELBY, C. F.—Oil burners for reverberatory furnaces. 1910. (In Engineering and Mining Journal, v. 89, pp. 31-32.) *The same, abstract.* 1910. (In Chemical Abstracts, v. 4, pp. 740-741.) Gives the design with a detailed drawing of a Shelby oil burner.

Furnaces.

Anthony oil melting furnace. 1910. (In Brass World, v. 6, pp. 213-215.) Illustrates and describes this type of metal melting furnace.

BELL, A. M.—Oil-fired furnaces. 1903. (In Cassier's Magazine, v. 25, pp 70-79.) Considers some of the applications for which oil fuel is especially adapted and gives illustrated descriptions of types of furnaces used.

BEST, W. N.—Petroleum as fuel under boilers and in furnaces for heating, melting, and heat treatment of metals. 1915. (In American Institute of Mining Engineers, v. 52, pp. 363-376.) Discussion.

CARR, W. M.—Small open hearth furnaces for steel castings. 1919. (In Iron Age, v. 83, pp. 466-467.) Illustrates and describes a small stationary open hearth furnace using liquid fuel, presenting its advantages.

COLES, GEORGE—Efficiency of oil tempering furnaces. 1910. (In American Machinist, v. 33, pt. 2, p. 490.) Describes a special kind of a furnace.

CONE, E. F.—Liquid fuel for foundry cupolas. 1915. (In Iron Age, v. 95, pp. 1058-1059.) *The same, abstract.* 1915. (In Chemical Abstracts, v. 9, p. 1737.) Oil used in cupola according to Stoughton patent reduces cost and increases rate of melting.

Convenient petroleum furnace. 1900. (In American Manufacturer and Iron World, v. 67, pp. 435-436.) An illustrated description of an economical apparatus used by Russians for ordinary forge work.

CRANE, W. E.—Crucible furnace for burning petroleum. 1894. (In Transactions of the American Society of Mechanical Engineers, v. 15, pp. 307-312.) With discussion.

Crucible furnace and oil burner. 1910. (In American Machinist, v. 33, pt. 1, pp. 942-943.) Briefly describes a furnace. Contains diagrams and figures.

Crucible steel casting practice. Description of the Milwaukee type of melting furnace, used extensively in steel foundries in the West. 1909. (In Foundry, v. 35, pp. 143-146.)

Description of the open hearth steel foundry. 1911. (In Iron Trade Review, v. 49, pp. 911-920.) *The same, abstract.* 1912. (In Journal of the Iron and Steel Institute, v. 85, pp. 515-516.) The equipment of the steel foundry of the National Brake and Electric Company of Milwaukee is described and illustrated. The large furnace is of the Campbell tilting type, and uses crude oil for fuel.

EVANS, H. A.—Oil burning melting furnace. (In American Machinist, v. 33, pt. 2, pp. 345-347.) Illustrated description of a furnace made of sheet metal and structural steel, lined with firebrick with a hearth of dolomite.

Faber du Faur zinc furnace. 1907. (In Engineering and Mining Journal, v. 83, p. 84.) Description with drawings of a special type of oil furnace.

Furnaces and stoves, gas and oil fired. 1916. (In Journal of the Institute of Metals, v. 16, p. 276.) Abstracted from *Mechanical World*, v. 60, June, 1916.) Furnaces for heating, annealing, hardening and similar processes are illustrated and described.

GREBEL, A.—Fours pour le traitement thermique des mètaux, chauffés au gaz de gazogène enrichi a l'huile lourde. 1914. (In La Génie Civil, v. 65, pp. 136-139, 160-162. *The same, review.* 1914. (In Journal of the American Society of Mechanical Engineers, v. 36, pp. -0162-0164. The article describes in detail the use of producer gas enriched by tar-oil for heat treatment of metals, especially furnace and methods used by the French concern "Air et Feu."

HALDANE, W. G.—Crude oil for the assay furnace. 1913. (In Engineering and Mining Journal, v. 96, pp. 1073-1074.) Gives advantages of liquid fuel, the rapidity, accuracy, and cleanliness of its use.

Heating 30 tons of forgings a day in oil furnaces. 1915. (In American Machinist, v. 43, pp. 273-275.) Convenience and economy are given as the main reasons for adopting oil furnaces. The article shows the arrangement of blowers, furnaces and hammers in the forge shop, and of the hardening and tempering furnaces for spring and drop forge dies.

Horner, J.—Oil furnaces for brass. 1918. (In Journal of the Institute of Metals, v. 19, p. 286.) Abstracted from *Mechanical World,* v. 61, p. 236, May 11, 1917. The advantages of such furnaces are the low consumption of fuel, regular temperature and no waste of heat. The oil furnaces of the Morgan Crucible Company are described and illustrated.

How an oil-fired malleable furnace operates. 1917. (In Foundry, v. 45, pp. 503-504.) *The same, abstract.* 1918. (In Chemical Abstracts, v. 12, p. 35.) Advantage lies in uniformity of operation and labor saving.

Improved melting furnace. 1918. (In Iron Trade Review, v. 63, p. 216.) *The same, abstract.* 1918. (In Journal of the Institute of Metals, v. 20, p. 351.) "This furnace for melting brass and other non-ferrous metals, is of the open-flame, non-crucible tilting type, with a capacity of 400 pounds. It is designed to use either gas or oil and the change from one to the other is said to be readily made."

Installs large reheating furnace. 1916. (In Iron Trade Review, v. 58, p. 929.) A continuous oil heating furnace of unusual size and design is illustrated and described.

Jacobs, E.—Blast furnace smelting with oil. 1911. (In Engineering and Mining Journal, v. 92, p. 434.) The results of experiments in Vancouver, B. C.

Lake, E. F.—Gas and oil fired furnaces for heating steel. 1914. (In Machinery, v. 20, pp. 747-750.) Types of furnaces used and important features of their construction. Illustrated.

Lake, E. F.—Over-fired and under-fired heat treating furnaces. 1910. (In American Machinist, v. 33, pt. 1, pp. 206-210.) Illustrates and describes oil-burning furnaces, their equipment and management.

Low-pressure oil burning furnaces. 1915. (In Metallurgical and Chemical Engineering, v. 13, pp. 510-511.) *The same, abstract.* 1915. (In Journal of the Institute of Metals, v. 14, p. 265.) The advantages claimed for the low-pressure burner over the high-pressure are freedom from noise, economy of fuel, and control of air supply.

MacGregor, Walter—Design of oil-fired open hearth furnaces. The construction of these melting mediums for the production of steel castings; calculations to obtain the sizes of the hearth, flues, etc. 1911. (In Iron Trade Review, v. 49, pp. 878-880.) *The same, abstract.* 1912. (In Mechanical Engineer, v 29, pp. 5-7.)

McNally, John—Oil furnaces. 1905. (In Iron Trade Review, v. 38, Sept. 14, pp. 20-21.) Presents some of the advantages and the economy made possible by the low pressure system now used. Discussion.

McVeen, E. H.—Melting brass turnings in the oil furnace. 1909. (In Brass World, v. 5, pp. 200-201.) *The same, abstract.* 1909. (In Chemical Abstracts, v. 3, p. 2668.) Gives the results of three years' experiences with oil furnaces.

Monarch bolt and rivet heating furnaces. 1910. (In Iron Age, v. 86, pp. 178-179.) *The same, abstract.* 1911. (In Journal of the Iron and Steel Institute, v. 83, pp. 607-608.) The improvements in these furnaces consist in means for the protection of the operator and a novel arrangement of the firebrick lining. Gives capacity of the furnace and consumption of oil per day.

Oil as fuel for open hearth furnaces. 1916. (In Journal of the Iron and Steel Institute, v. 92, pp. 278-279.) A series of tests of atomizing fuel oil with steam and air in open hearth steel furnaces.

Oil-burning cupolas. 1916. (In Petroleum Review, v. 34, p. 170.) *The same, abstract.* 1916. (In Journal of the Iron and Steel Institute, v. 93, p. 320.) This shows the results of the working of two cupola plants arranged for oil-firing.

Oil burning forges and heaters. 1909. (In American Machinist, v. 32, pp. 776-779.) Illustrates and describes types of forge furnaces and other heaters.

Oil burning steel heat treating furnace. 1909. (In American Machinist, v. 32, p. 134.) Description of a furnace made by Tate, Jones & Co., Pittsburgh, Pa.

Oil-fired case hardening furnace. 1917. (In Engineer, London, v. 124, p. 570.) *The same, abstract.* 1918. (In Journal of the Iron and Steel Institute, v. 97, p. 525.) An illustrated description is given of an oil-fired case-hardening furnace. The oil-fuel burner is fitted at the back of the furnace and a special spreading arrangement distributes the heat uniformly below the floor.

Oil-fired furnaces for foundries. 1912. (In Journal of the Iron and Steel Institute, v. 86, pp. 543-544.) Abstracted from *Giesserei Zeitung,* v. 9, pp. 24-27, 48-52, 75-78.) The advantage lies in the simplicity and cheapness. The consumption of oil is about 50 gallons per ton of steel produced.

Oil-fired re-heating furnace. 1913. (In Engineer, v. 116, p. 47.) *The same, abstract.* 1913. (In Journal of the Iron and Steel Institute, v. 88, p. 638.) Illustrated article of furnace using a Brett oil burner especially designed for heating buffer blooms.

Oil fuel in the foundry. 1911. (In Journal of the Iron and Steel Institute, v. 84, p. 560.) Abstracted from *Giesserei Zeitung,* v. 8, pp. 373-384.) Gives the principles of the construction of oil-fired furnaces and comparative tests with oil-fired and coke-fired furnaces.

Oil furnaces for rivet-heating. 1909. (In Journal of the Iron and Steel Institute, v. 80, p. 443.) Abstracted from University of Birmingham *Engineering and Mining Journal,* v. 7, pp. 150-153. The data given show a remarkable economy as compared with the cost of heating with coal.

Schweitzer, L.—Oil-fired open hearth furnaces. 1917. (In Journal of the Iron and Steel Institute, v. 96, p. 404.) Abstracted from *Stahl und Eisen,* 1916, v. 36, pp. 1174-1180.) A description of furnaces at steel works in Monterey, Mexico.

Oil-gas-fired furnace. 1915. (In Journal of the Institute of Metals, v. 13, pp. 364-365.) Abstracted from *Mechanical World.* 1914. v. 16, p. 285.) An illustrated description of furnaces in which the Burdon system of burning liquid fuel is applied

Plant, A. E.—Use of oil fuel in the foundry in urgent exceptional circumstances. 1918. (In Journal of the Institute of Metals, v. 20, pp. 257-261.) Use made of an oil furnace for melting aluminum and gunmetal scrap by British soldiers while in France.

Ploehn, J. H.—Open hearth furnace design and manipulation as adopted for foundry work. 1912. (In American Foundrymen's Association, v. 21, pp. 357-372.) *The same, abstract.* 1913. (In Journal of the Iron and Steel Institute, v. 87, p. 611.) Description of 25 ton basic open hearth furnaces operated on fuel oil.

Portable railroad shop tools. 1910. (In American Machinist, v. 33, pt. 2, p. 217.) Describes a portable oil furnace.

Primrose, H. S.—Metal melting in a simple crude-oil furnace. 1917. (In Journal of the Institute of Metals, v. 17, pp. 251-255.) *The same, abstract.* 1917. (In Chemical Abstracts, v. 11, p. 1622.) *The same, condensed.* 1917. (In Iron Age, v. 99, p. 1499.) Describes construction, advantages and melting results of a furnace used largely for brass melting.

Ring, Hans—Anlage und Betrieb eines Klein-Martin-Ofens mit Teerölfeuerung. 1914. (In Stahl und Eisen, v. 34, pp. 1424-1428.) *The same, abstract translation.* 1915. (In Journal of the Iron and Steel Institute, v. 91, p. 561.) An illustrated description of a 1-ton open hearth furnace with tar oil-firing for steel foundry work.

Skov, H.—Oil fuel for metallurgical furnaces. 1916. (In Journal of the Iron and Steel Institute, v. 93, pp. 319-320.) *Abstracted from Tekniske Forenings,* 1915, v. 39, pp. 105-109.) Illustrates and describes various types of furnaces. The cost of oil firing compares favorably with that of coal, coke or gas.

Smelting iron ore with crude oil. 1902. (In Engineering and Mining Journal, v. 74, pp. 854-855.) *The same, abstract.* 1903. (In Journal of the Iron and Steel Institute, v. 63, p. 646.) An illustrated description of the Riveroll smelting furnace and its method of using fuel oil.

Spillman, H. C.—Kerosene for steel heating furnaces. 1913. (In Machinery, v. 20, pp. 125-126.) Arrangement of a well equipped heat treating department. Comparative values of fuel oil and kerosene.

Stone, J.—Oil fired furnaces for foundries. 1913. (In Journal of the Iron and Steel Institute, v. 87, p. 611.) Abstracted from *Foundry Trade Journal,* 1913, v. 15, pp. 233-234. Deals briefly with the subject and points especially to protection of metal while melting.

Stoughton, Bradley—The oil-fired cupola. 1915. (In Transactions of the American Foundrymen's Association, v. 24, pp. 525-529.) Discussion, pp. 530-535.

Uren, S.—Care, use and design of oil furnaces. 1905. (In Proceedings, Pacific Coast Railway Club, v. 7, pp. 62-69.) Discusses questions of the economy of oil, as compared with coal, the effect on the material, and the latest improvements in furnace doors, firebrick, burners, etc.

Use of oil in metallurgical furnaces in Russia. 1900. (In Engineering and Mining Journal, v. 69, pp. 739-740.) Showing that oil has become a valuable fuel in all metallurgical operations. Illustrated with figures.

Venator, W.—Oil-fired furnaces for foundries. 1913. (In Journal of the Iron and Steel Institute, v. 88, pp. 599-600.) Abstracted from *Giesserei Zeitung,* 1913, v. 10, pp. 101-103, 137-141. Gives an account of the progress in the use of fuel oil and the results obtained with tar oil.

Waters, A. L.—Experiments with an oil-burning shaft furnace. 1913. (In Engineering and Mining Journal, v. 96, pp. 203-205.) *Synopsis*: A record of experiments on an oil-burning shaft furnace. The experiments were promising, but had to be abandoned for lack of capital. Further investigation is indicated.

Operation.

Baillie, A. F.—Oil and its application. 1918. (In Iron and Coal Trades Review, v. 96, p. 92.) *The same, abstract.* 1918. (In Journal of the Iron and Steel Institute, v. 98, p. 457. The appendix contains details of comparative cost of fuel oil, coal, coke and gas for metallurgical work.

Best, W. N.—The equipment of air furnaces using oil as fuel. 1912. (In Transactions of the American Foundrymen's Association, v. 20, pp. 421-424.) Describes the operation of an air furnace and deals with problems that often confront users.

Best, W. N.—Liquid fuel for furnace equipment. 1905. (In Scientific American, v. 106, p. 282.) On the increasing use of liquid fuel and its success in forges and furnaces.

Best, W. N.—Liquid fuel in the foundry. 1912. (In Foundry, v. 40, p. 489.) *The same, abstract.* 1913. (In Chemical Abstracts, v. 7, p. 757.) Analyses and properties of various fuel oils are given. The necessity for the thorough atomization of the oil is emphasized.

Best, W. N.—Oil firing in foundry practice. 1915. (In Iron Age, v. 95, pp. 870-871.) Gives some practical suggestions, describes one type of oven used and treats of modern brass melting.

Best, W. N.—Science of burning liquid fuel. 1904. (In Scientific American Supplement, v. 58, p. 23936.) Considers some of the advantages of this fuel over others, and how to obtain the best results.

Best, W. N.—Use of liquid fuel in foundry practice. 1912. (In Iron Age, v. 90, p. 941.) *The same, abstract.* 1913. (In Journal of the Iron and Steel Institute, v. 87, p. 611.) "Makes a superior grade of metal and is regular in its effects. Very accurate temperatures can also be obtained when using liquid fuel, the chief advantage being that the fire can be kept under perfect control, and can attain and maintain the heat required at all times."

Bull, R. A.—Atomizing fuel oil. 1915. (In Iron Age, v. 96, pp. 1049-1050.) *The same, abstract.* 1916. (In Chemical Abstracts, v. 10, p. 165.) Tests to determine the relative advantages and disadvantages of atomizing fuel oil with steam and with air.

Bull, R. A.—Tests in atomizing fuel oil with steam and air. 1915. (In Foundry, v. 43, pp. 424-427.) *The same, abstract.* 1916. (In Journal of the Iron and Steel Institute, v. 93, p. 345.) Tests carried out in atomizing fuel oil with steam and air, in order to ascertain the relative economies of these methods as applied to open hearth furnaces.

Cone, E. F.—Liquid fuel for foundry cupola. 1915. (In Iron Age, v. 95, pp. 1058-1059.) Discusses use according to Stoughton patent, cost reduction, and increased rate of melting.

Crude oil in the cupola. Bradley Stoughton explains new process to Newark foundrymen. Answers questions. 1916. (In Iron Age, v. 97, p. 376.)

Dickson, W. S.—Advantages offered by the oil-fired cupola In the process described, crude oil is sprayed directly onto the coke bed to increase the heat and to reduce the amount of coke consumed. 1918. (In Foundry, v. 46, pp. 381-382.)

Experiments in oil-smelting in British Columbia. 1912. (In Metallurgical and Chemical Engineering, v. 10, pp. 543-544.) Describes a series of experiments for smelting ores in an attempt to perfect or render practicable an oil fired furnace. Describes the particular furnace used and success achieved.

Fuel oil vaporizer. 1910. (In American Machinist, v. 33, pt. 2, pp. 125-126.) Gives details of vaporizer for oil-burning furnaces.

Hall, J. H.—Burning oil in cupolas. Recent developments in the use of the Stoughton process in a converter foundry. 1918. (In Iron Age, v. 102, p. 1142.)

Hall, J. H.—Oil-burning cupola operations analyzed. Results attained in melting iron for a three-ton converter plant point to saving in fuel and labor with more steady output. 1918. (In Foundry, v. 46, p. 558.) *The same.* (In Iron Age, v. 102, pp. 1142-1143.)

Hamilton, E. H.—Use of oil for smelting. 1911. (In Engineering and Mining Journal, v. 91, pp. 224-225.) *The same, abstract.* 1911. (In Chemical Abstracts, v. 5, p. 1057.) The way oil has been successfully used in reverberatory furnaces.

Liquid fuel for cupolas. 1915. (In Iron Age, v. 95, p. 482.) Describes briefly the patent taken out by Dr. Bradley Stoughton for supplying heat with liquid fuel.

Liquid fuel for melting. 1915. (In Iron Trade Review, v. 57, pp. 222-223.) Treats of the patent granted to Dr. Bradley Stoughton, that is designed especially for foundry cupolas.

McFarland, A. F.—Application of heat in steel treating. 1918. (In Iron Age, v. 101, pp. 612-614.) "Principles of Generation by Electricity, Gas, Oil or Powdered Coal."

Making steel castings by the crucible process. 1912. (In Foundry, v. 40, pp. 339-346.) Discussion of the molding and melting practice of a large Milwaukee foundry, with a few hints on gating. Contains illustrations and diagrams.

Marquand, A. B.—Smelting with crude petroleum. 1915. (In Canadian Mining Journal, v. 36, pp. 472-474.) Gives results of experiments carried on in California and treats especially of the elimination of sulphur dioxide and the control of flue dust in the smelting of base metal ores.

Notes on reverberatory smelting practice of Nevada Consolidated Copper Company. 1915. (In Metallurgical and Chemical Engineering, v. 13, pp. 681-682.) Records made by a careful study of using crude oil for smelting.

Oil-burning cupolas. Results of recent practice with the Stoughton process. 1916. (In Iron Age, v. 97, p. 232.)

Oil-fired settlers at El Paso. 1915. (In Engineering and Mining Journal, v. 100, pp. 356-357.) Method employed in smelting lead.

Pearce, G. P.—Liquid fuels for heating furnaces. Fixing value of fuel oils for metallurgical furnaces on a Btu basis. 1917. (In Machinery, v. 23, pp. 615-616.)

Preiner, J.—Verwendung von fluessigem Brennstoff fuer huettenmannische Zwecke in Russland. 1900. (In Stahl und Eisen, v. 20, pp. 424-452.) *The same, abstract translation.* 1900. (In Journal of the Iron and Steel Institute, v. 58, pp. 449-452.) Discusses chiefly the importance and the development of the metallurgical processes in Russia.

Stock process for steel castings. 1911. (In Iron Age, v. 88, pp. 524-526.) *The same, condensed.* 1912. (In Mines and Minerals, v. 32, p. 565.) *The same, condensed.* 1912. (In Iron and Coal Trades Review, v. 84, p. 643.) *The same, abstract.* 1912. (In Journal of the Iron and Steel Institute, v. 85, pp. 517-518.) Results attained by using a small Bessemer converter equipped with an "economizer" and using fuel oil for melting at the Darlington Forge Works.

Stoughton, Bradley—How crude oil is used for cupola melting. The cost of fuel is greatly reduced, the process can be advantageously controlled and some coke is used in the furnace. 1916. (In Foundry, v. 44, pp. 303-304.)

Successfully operating a 3-ton open hearth. How steel is made in a small, oil-fired furnace, designed to operate on Mexican fuel, utilizing waste heat from crucible battery. 1914. (In Foundry, v. 42, pp. 109-113.)

Ulrich, J. E.—Oil furnaces and the economical handling of oil as fuel. 1909. (In Iron Trade Review, v. 44, pp. 1038-1040.) *The same, abstract.* 1910. (In Chemical Abstracts, v. 4, p. 658.) Treats specially of combustion from the chemical standpoint and deals with furnace construction.

Use of petroleum in smelting iron. 1902. (In Journal of the Iron and Steel Institute, v. 62, p. 477.) Abstracted from *Chemiker Zeitung,* v. 26, pp. 222-223.) Solid fuel is used with petroleum.

Heating Furnaces and Annealing Furnaces

Heat Transmission Coefficients for Regenerator Are Developed from Plant and Laboratory Tests—Curve Sheets Are Given for Quick Determination of Regenerator Size of Any Furnace.

By **W. TRINKS.**

PART. VIII.

When heat regenerators are used in connection with blast furnaces and with open hearth furnaces, the attaining of a given minimum furnace temperature is essential for the carrying out of the desired metallurgical process. No such minimum temperature exists in heating furnaces or in annealing furnaces, and in connection with such furnaces regenerators are avowedly used for the sole purpose of increase of fuel economy, against which must be charged increased first cost and cost of upkeep. From the fuel saving due to a given preheat, from the unit cost of fuel, from the size of the regenerator for a given preheat, and from its cost, the best commercial size of regenerator can be calculated. The ratio of cost of fuel to that of regenerator varies considerably in different localities, as well as in different times, and for that reason it is impossible to give general rules for the best size of regenerator.

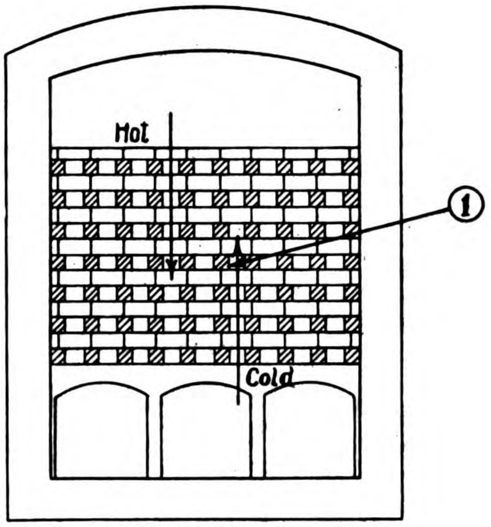

Fig. 53.

On the other hand, it is quite feasible to compute the size of regenerator which is necessary to secure a desired preheat for a given furnace (compare the curves in the present installment). Likewise, the final saving due to that same degree of preheat is known from the curves of Part VI of this series. The two sets of curves can easily be combined for an individual case for which cost of fuel and cost of regenerator construction are known.

The solution of the problem of determining the required size of regenerator for a given furnace and preheat is indeed difficult, if it is to be scientifically complete, because of the great number of variables.

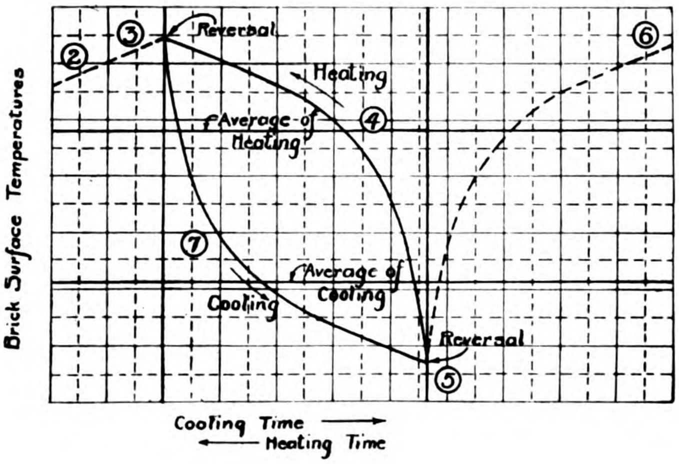

Fig. 54.

The temperature in the regenerator tiles varies both with place and with time; the heat conductivity of the brick varies with the temperature; and the heat transmission coefficient from gas to brick varies with gas-density and gas-velocity. Fortunately, a solution which is quite satisfactory for practical purposes can be obtained without recourse to the differential equations of heat transmission.

The questions, as put by producing practice are these: What heating surface is necessary? What volume of regenerator chamber is necessary? What depth of regenerator is necessary? In case producer gas is used, the ratio of air chamber to gas chamber furnishes an additional problem.

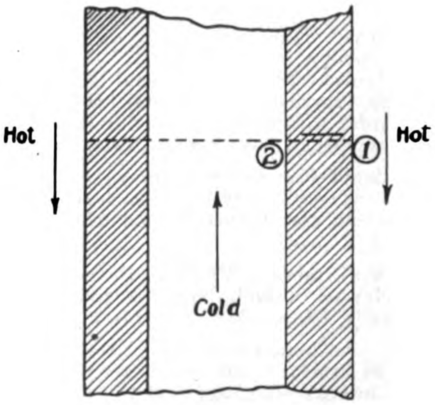

Fig. 55.

All of these problems can be solved with comparative ease by the virtual substitution of a thick walled recuperator in the place of the actual regenerator. Proof will now be furnished that such a substitution is justified, both from a scientific standpoint and from a practical standpoint.

If the surface temperature of any brick in any regenerator, for instance heat of brick (1) in Fig. 53, is plotted against time, the resulting curve assumes the shape shown in Fig. 54. The line (2), (3), (4), (5), (6) shows temperature plotted against continuously advancing time, while the closed line (3), (4), (5), (7), (3) indicates the fluctuations of surface temperature within one cycle. A glance at Fig. 54 is sufficient to show that the average temperature for the heating period and for the cooling period do not coincide and that the temperature of the wall into which heat is flowing considerably exceeds that of the wall out of which heat is flowing. But that is exactly the case at any section of a thick walled recuperator, for instance in the plane (1) (2) of Fig. 55 in which plane point (1) has a temperature considerably in excess of that of point (2). From part VII of this series it is known that the temperature drop through the wall of a recuperator reduces the overall heat transmission coefficient. And that is exactly what happens. The equivalent heat transmission coefficient in regenerators is lower than it is in thin walled metal recuperators.

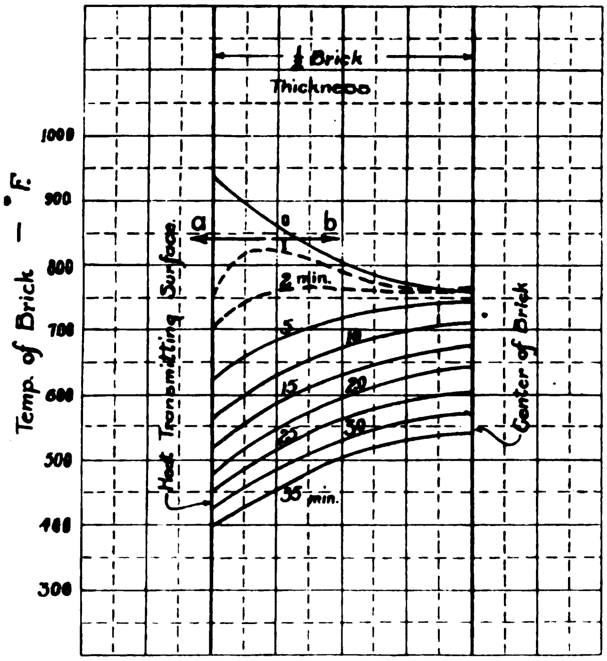

Fig. 56.

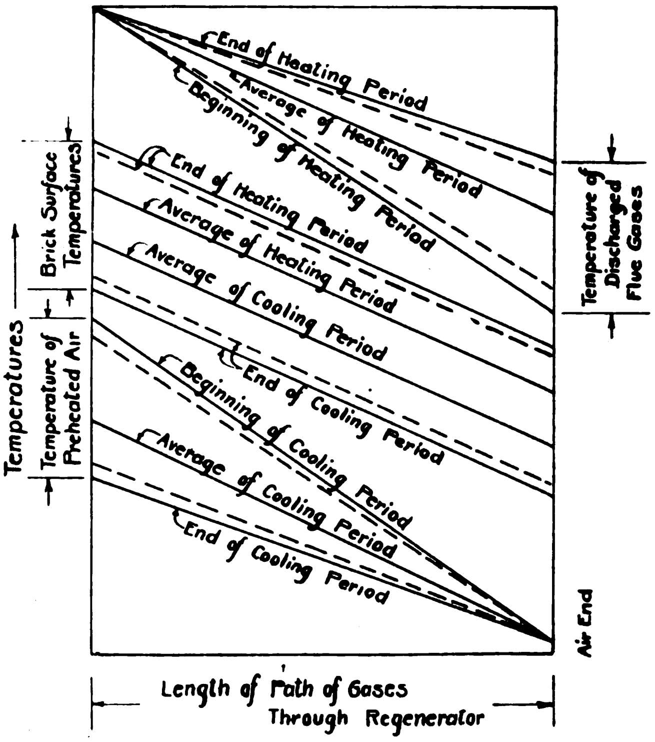
End of Heating Period
Average of Heating Period
Beginning of Heating Period
End of Heating Period
Average of Heating Period
Average of Cooling Period
End of Cooling Period
Beginning of Cooling Period
Average of Cooling Period
End of Cooling Period
Temperatures
Brick Surface Temperatures
Temperature of Preheated Air
Temperature of Discharged Flue Gases
Air End
Length of Path of Gases Through Regenerator

Fig. 57.

The next steps in the argument logically are: What causes the temperature distribution of Fig. 54, how does it vary with the conductivity and with the thickness of the brick and how is it influenced by the frequency of reversals? For an answer to these questions follow the temperature distribution (see Fig. 56) in a brick or a regenerator wall section somewhere near its center. For instance at brick (1), Fig. 53, the temperature distribution shown in Fig. 56 was plotted from tests made by J. D. Keller in the mechanical engineering laboratory of the Carnegie Institute of Technology, where a regenerator was set up especially for making tests for the present series of articles. The lines of Fig. 56 show the temperature distribution throughout the heat exchanging part of a regenerator immediately following the reversal from heating to cooling. The figures on the lines give the minutes which have elapsed between the time of the reversal and the time for which the temperature distribution is indicated by each line. It will be noted that heat flows both ways (see arrows "a" and "b") immediately following the reversal; but the skin temperature drops so rapidly that heat flow into the brick ceases after one minute and the somewhat parabolic lines marked 5, 10, 15, 20 minutes, etc., establish themselves. The temperature change in the heat exchanging skin is most marked in the first few minutes after reversal, from which circumstance follows the conclusion that the time average of temperature of a regenerator surface will, during the period of heating, always be much greater than during the period of cooling. It may be argued that the variation of skin temperature is not as great for frequent reversals as it is for longer periods between reversals. Doubtless, such a statement is true, but the frequency of reversals, (within the limits of practice) have no noticeable effect upon the rate of heat transmission, because the average temperature difference between brick surface and heat transmission gases remains practically constant, although, of course, it affects the fluctuations of the temperature of preheat. The essential features of temperature distribution are diagramatically shown in Fig. 57, which illustration is worthy of some study. In it, the abscissae denote position of brick, or length of flue gas travel in regenerators, while the ordinates represent temperature. The solid lines hold for a long time between reversals, while the dotted lines hold for a shorter time between reversals. While the temperature range between the final values varies with the length of time between reversals, the average values remain practically the same and vary so little that only one line was used for them in the diagram.

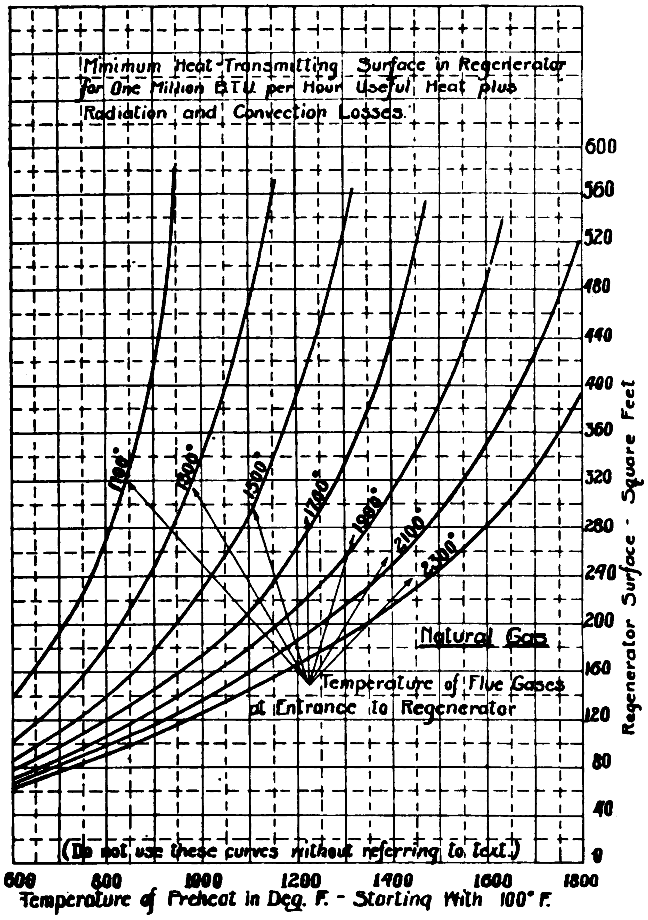

Fig. 58.

The conductivity of the heat storing material will have a decided influence on the equivalent coefficient of heat transmission. If bricks of the conductivity of silver could be used, the temperature lines in Fig. 56 would be almost horizontal, which means that the temperature of the interior of the brick would fluctuate almost as much as that of the surface, and the bricks would be utilized better. However, we are tied down to the use of firebrick for the heat storage material, so that variations of heat transmission coefficient on account of variations of conductivity need not be considered.

The influence of varying thicknesses of brick need not concern us either, because by far the greatest number of regenerators are laid up with standard bricks.

There remain the variations brought in by different rates of gas flow. But again we can disregard these variations, because practical considerations keep the gas velocities within very narrow limits. If regenerator bricks are laid too open, the gas will pass through without touching the brick. If they are packed too close, the friction resistance will be too great. For this reason the bricks are commonly so laid that one third of the horizontal cross sectional area is available for free flow of gas, while at the top a little more, say up to one-half, is occasionally allowed. In each layer taken by itself the area between the bricks exceeds this amount. With this spacing of the bricks and with the depth of regenerator usually available, all of the draft produced by the heat of the regenerator is dissipated by friction and velocity heads with a velocity of 2 to 2½ feet per second through aforesaid free area.

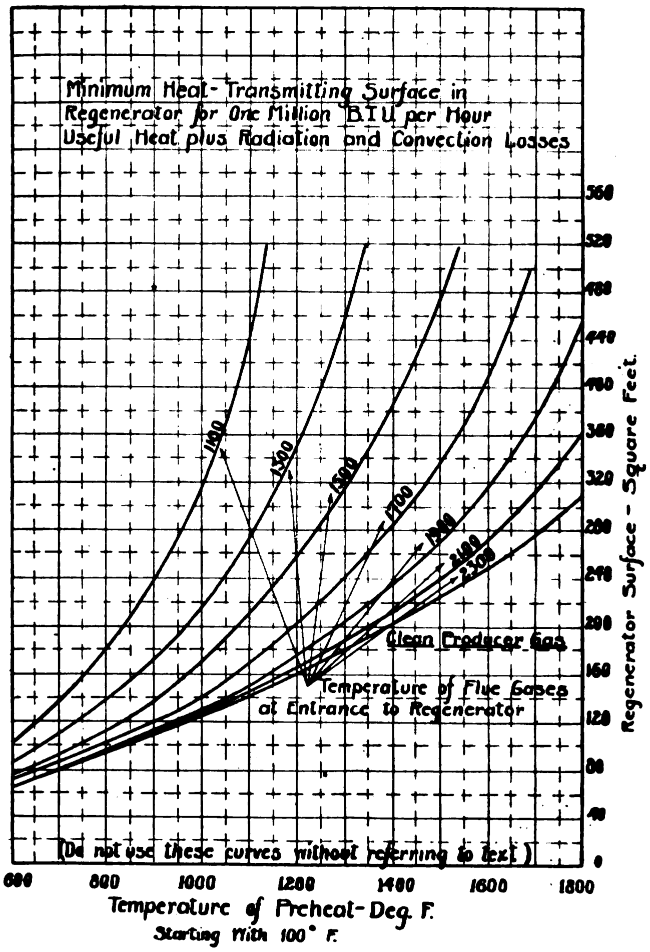

Fig. 59.

Taking all of these limitations into account, we find that the overall heat transmission coefficient must necessarily vary within comparatively narrow limits, which limits from the Carnegie Tech tests and from other tests appear to lie between 1.1 and 1.8 Btu sq. ft. degrees F. and hour.

The curves in Figs. 58, 59, 60 and 61 have been computed on the basis of a coefficient of 1.4 Btu sq. ft., degree F. and hour. The surface which is obtained refers to one side of the furnace only. With standard design of regenerators, 1,000 square feet of heating surface require from 230 to 280 cubic feet of checker volume, which latter volume refers to the checker chamber only. Distribution ducts below and above the checker are not included in the volume thus given.

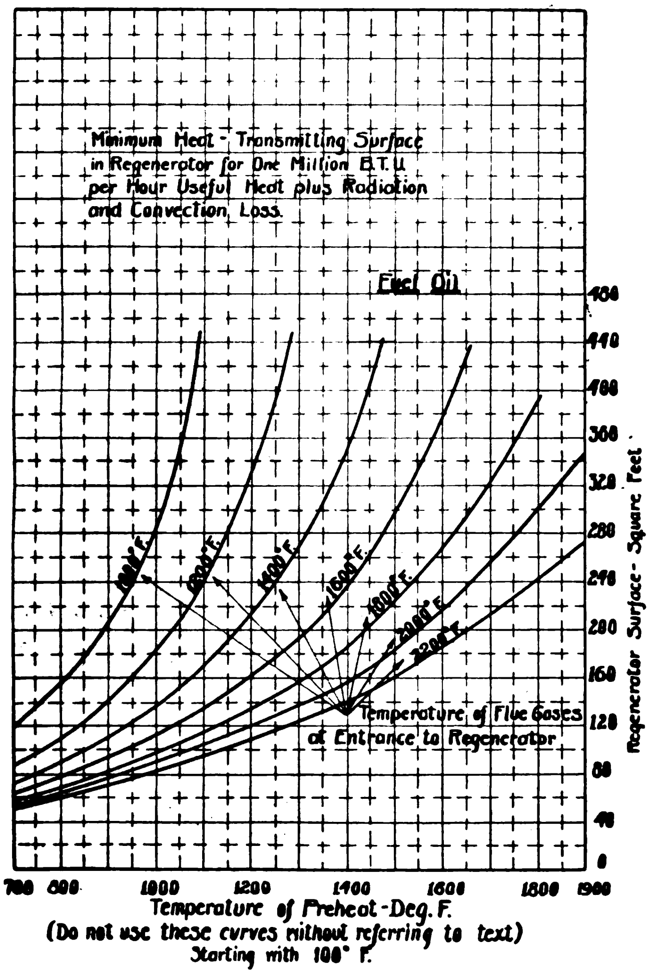

Fig. 60.

In general, the curves are similar to those given in part seven for recuperators, and the same precautions must be applied in their use. In particular, the interior walls of the chamber, of the vertical flues and of the fantailed ducts up to reversing valve act as regenerative surface, and an approximate reduction may be made, if that wall surface is large, and if the regenerator is buried in the ground. The surface of the walls of the chamber, ducts, and of the supporting tiles easily amounts to one-fifth of the surface of the bricks in the checker chamber. If the regenerator is exposed, the heat loss through the walls is considerable and reduces the efficiency of the regenerator to a very large extent. The complete mathematical investigation of this condition exceeds the limits of this elementary part of the treatise.

As an example consider a furnace with heat requirement of 3,500,000 Btu per hour for heating steel, heating brick walls, balancing radiation and convection, water cooling, etc. Let the furnace temperature be 2,300 degrees F., and let the desired temperature of preheat be 1,800 degrees F. For natural gas as fuel, the curves of Fig. 58 give a heating surface of 400 sq. ft. per 1,000,000 Btu/hour. Hence the heating surface per regenerator must be $\frac{3{,}500{,}000 \times 400}{1{,}000{,}000} =$ 1,400 sq. ft. Since for 1,000 sq. ft. the required checker chamber volume equals 250 cubic feet, on the average, the volume of each of the checker chambers for the furnace in question will be 350 cubic feet.

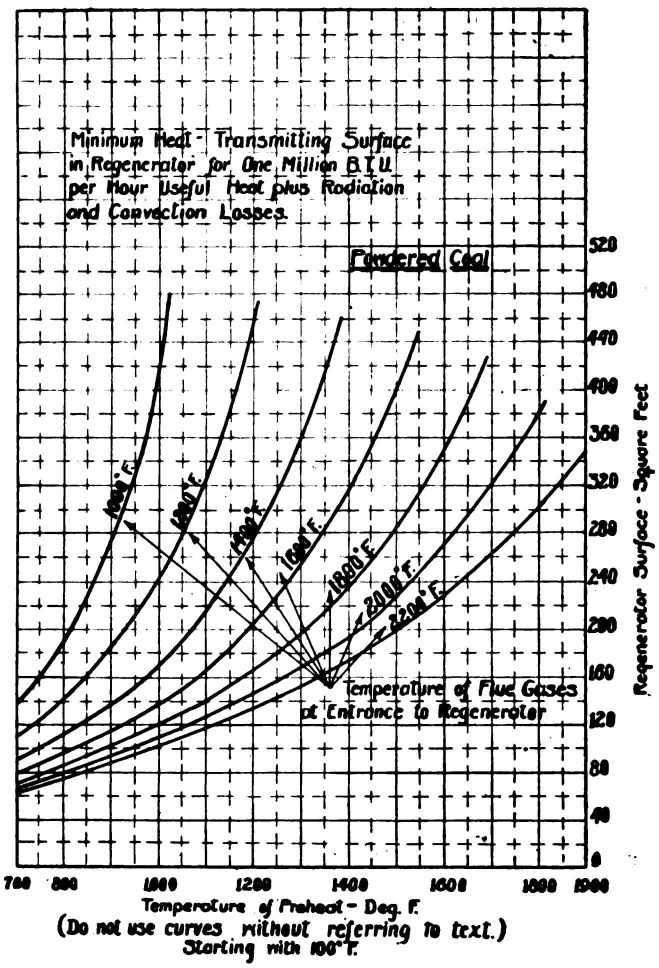

Fig. 61.

Relations Between Employer and Employe

Labor Relations Analyzed—Planning a Labor Relations Policy. Creating the Labor Administration Organization—Operating the Labor Administration Machinery—Canvassing Labor Needs.

By DR. WILLIAM M. LEISERSON,
Chief, Division of Labor Administration.

Two sets of labor relations must be clearly distinguished in any plan or policy of labor administration for industrial enterprises:

1. Personal relations; the management problem.
2. Economic relations; democracy problem.

The first presents the problem of dealing with the human element that goes into production, with due regard for feelings, instincts, prejudices, ambitions and ideas of their own worth that wage earners like all other human beings have. The second is an entirely different problem having to do with the division of the wealth created by industry and with the government or control of the industry. The first covers such questions as hiring, selection, placement, training, promotion, treatment by foremen, health, safety, fatigue, recreation, lunches and rest periods. The second is concerned with bargaining, wages, hours, unionism and shop discipline.

The personnel problem of administering the labor forces in industry on the principle that wage earners are human beings and not some abstract thing called labor, ought not to be a mater of industrial controversy. The personal treatment that working people receive at the hands of their employers, their handling by superintendents, foremen and strawbosses is not properly a controversial subject. Each individual worker has certain qualities, characteristics and capacities, and the management must understand these, as well as it understands the materials and the mechanical power that it uses. The failure to develop and train these capacities is one of the great sources of waste in industry. The employer must not expect a worker to give results or stand strains beyond his capacity any more than he expects an engine or a bridge to do it.

Safety and sanitation in industry are technical problems for experts to decide, rather than problems for employers and employes to fight about. What constitutes a safe and a healthy place of employment is a subject for the safety engineer and the medical man to decide. In the same way, the proper handling of human beings is a technical problem that requires careful study and also sympathetic understanding. Just because a man knows how to make a certain part of a shoe or a shirt or a machine, is no reason for making him a foreman or a superintendent, thereby giving him authority over the lives and welfare of other employes. We expect a stationary engineer to know something about a boiler or an engine before he is licensed to operate one. Just so, before anyone is permitted to handle human beings in a plant, to make rules and regulations for them and to require performance from them he must be required to show some expertness in understanding human being. The work of dealing with these personnel problems in industry that are not essentialy controversial, belongs to a personnel or labor manager who should have the same capacity and authority in handling the labor of the plant that the sales manager, the financial director and the production manager have in handling the problems with which they are concerned.

The return that workers should get for their labor, the number of hours they shall work, the share they shall have in fixing the terms of employment, and whether they shall do their bargaining collectively, through their own chosen representatives or organizations—these comprise the modern industrial or business relations between employer and employe; and they represent controversial issues that cannot be solved by any technical expert. They require settlement by negotiation and bargaining and they will be settled from time to time in accordance with the relative strength and bargaining power of the parties to the controversy.

Planning a Labor Relations Policy.

It is the chief executives of the company who must determine the labor policy of a plant. In the past it has been customary for the chief executives to deal only with the production, finance and sales problems. Labor was left as an incidental matter for production superintendents and foremen to handle. Only when labor difficulties arose was labor considered important enough for the directors to handle and at such times subordinate officers had already committed the company to a policy that the directors were bound to uphold. Only by determining the labor policies in the board of directors' meetings where they can be corsidered in conjunction with production, finance and sales policies, can a proper system of labor relations be advised and kept in constant operation.

If the chief executives of the company are to deal with labor, one of the first needs is to set up data-collecting machinery that will present to the management from day to day, exact conditions. In other words, the management must keep a continuous labor inventory. But not only must the labor record system show the condition of labor in the aggregate, it must show the career of the individual worker in the plant. Too often the keeping of individual records confines itself to watching what the company is getting out of the man. Equally important is the record of what the man is getting out of the company. If the same importance is attached to keeping a record of the company's performance of its duties to the worker as to recording the man's performance for the company, there will be little opposition to a careful record system. In all cases care must be taken not to make the records over-elaborate, and the management must watch itself constantly to prevent the keeping of records from becoming an end in itself. Every record is superfluous that is not used in administering the labor policies of the plant.

Many so-called consulting experts on employment management and industrial relations, failing to catch the distinction between the purely personal and the industrial problems arising in the relations between employer and employe, often mislead business men into thinking that if they will establish a centralized employment department, install certain methods of record keeping and adopt a certain procedure in selecting and dismissing employes, all their labor problems will be solved. Other "experts" there are who have some one system of shop organization or efficiency records or method of analyzing and classifying human character, which they try to sell to employers as a solution for all labor difficulties. The employer, himself, dismayed by a large labor turnover, seeing distrust and unrest among his employes, and fearing strikes and "Bolshevism," is inclined to seek relief in some patent device. He seizes upon profit-sharing or shop committees or some plan of representation of employes as a panacea for all his ills. Patent medicines do not cure bodily ills caused by bad living, and there is no single medicine that will cure industrial ills brought on by bad management of the human forces in industry.

Having determined what to avoid, the employer must make up his mind as to the exact nature of the improvement in labor relations that is needed in his plant and how far he is willing to go in making improvements. It is quite common for the owner of a business to say that he wishes his employes to have the best conditions, the best treatment and an absolutely square deal. But this is a general wish and the employer must decide specifically what he is willing to do to insure these things. The employes may feel that they never can have a square deal until they have an equal share in controlling discipline in the shop. Is the employer ready to turn over this shop control to the employes? Is he ready to deal collectively with his employes, or does he merely want to insure them an individual square deal in accordance with his own ideas of justice? If he is willing to deal collectively with his employes he must decide whether he will recognize a union or deal with representatives from among the employes; and if only with his own employes, then are they to have advisory powers only or an equal voice with the management in determining all questions? These things must be decided in advance. An undecided or vacillating policy makes the employes feel that the employer is not honest with them. They feel what the employer's labor policy really is in their daily experience in the shops and it is important for the employer to see that this experience is in accord with his announced labor policy.

Quite as important as deciding the policy itself is to make sure that the employes have the same understanding of the policy of the management in relation to labor as the employer himself has. Often a firm will announce an employment system, or a profit sharing or shop committee plan, with a statement that it wishes to establish democratic relations with its employes and give them a voice in determining conditions of employment. To the employes this means collective bargaining or a veto power on any policy of the management that they may not like. But the employer may not intend it that way and the plan itself often shows that he wishes to maintain control, and merely desires to provide means of consulting with his employes and providing for their welfare. This leads to misunderstanding and causes the very friction that the plans are intended to remove.

It is important that the management shall make no promises to the employes which it has not the machinery for making good. It is most common for employers to promise promotion to deserving employes, yet there are very few plants which have any organized plan for finding out what employes deserve promotion and of making that promotion when it is deserved. The usual procedure is to wait until the employe asks for a raise or a better job. It is quite natural, therefore, for the employes to think that the employer tries to deceive them with false promises. They resent having to beg for the increases and the better jobs that they feel the management ought to take the initiative in giving them; and they know that the men who are good at asking for raises usually get farther ahead although they may not be the most deserving. If any promises are made they must be considered as in the nature of contracts. The means of keeping the promises must be created. If no machinery is in existence for fulfillment, then care must be taken to make no promises so as to raise no false hopes.

If the employer has a small plant and is in daily touch with all his employes he need have little difficulty in making his labor policies work out in practice as he intends them. But as a matter of fact he is usually in an executive office far removed from the foremen and strawbosses who have the direct handling of labor in charge. These quite commonly pursue policies of their own that may not at all be in accord with the employer's intention. To translate the owner's wishes into actual performance, therefore, it is necessary to create an administrative organization for carrying out the labor policies of the plant, to give authority, fix responsibility, provide for appeals and maintain constant supervision that will keep the machinery operating properly.

Creating the Labor Administration Organization.

Creating the machinery of labor administration in a plant becomes a simple matter when the nature of labor relations is properly analyzed and a definite policy of labor management is decided upon by the chief executives of the company with due consideration of the analysis. Basic in any plan of properly handling labor is a centralized organization for handling all the employment functions. The man put in charge of this work is commonly known as the employment manager. While it is important that he should know the occupations and the nature of the work the men he selects are to do, it is more important that he should know thoroughly the kind of human beings that apply to the plant for work and the kind of work they can do.

In addition to handling employment problems the management must provide for the human needs that develop from the mere congregation of a large number of human beings under one roof. There are the problems of health, sanitation and medical care, safety and composition, education of the foreigner, the illiterate and the juvenile employes, providing eating, rest and recreation facilities, insurance, pensions and other welfare activities.

The employment and service organizations deal with the personnel problems and are intended to provide efficient and humane handling of the labor force of a plant. To many this will seem sufficient; but it should be clearly understood that this does not touch the industrial relations problem nor does it provide for democratic control of working conditions and terms of employment. Realizing this, some employers try to provide democracy by creating shop committees to advise and to consult with the management about the various employment and service problems. But this does not insure democracy unless the employes vote on the rules and regulations by which they are governed, and have the right of a trial by their peers when disciplined for infringement of any rule. If the employer really means to have democratic management of his labor force, then he must provide for collective bargaining with his employes and give them a voice in controlling discipline.

Democracy or partnership in labor management requires an industrial relations organization designed to place the employes and the employer on an equality in bargaining power and to give them an equal voice in determining working conditions and terms of employment. Such an organization consists of employes' representatives, sometimes known as shop stewards or shop chairmen, employes' committees dealing with wages, hours, grievances and discharges, and an arbitration board of some kind to decide differences between the management and the employes. If the employer is not prepared to give his employes an equal voice in labor bargaining and shop government, he should avoid creating any committees or boards which give the appearance of collective bargaining but not the essence. Employes are quick to sense the difference in their daily experiences in the shop, and they think the employer is trying to deceive them.

The most advanced form of labor administration obtains in a few firms which have a vice president in charge of labor, or a labor manager equal in rank and authority with the production, sales and financial managers. A large clothing concern, for example, divides its operations into five departments, purchasing, production, labor, sales and finance. At the head of each is a manager and the five together constitute the executive organization of the business. No important policy is decided upon by anyone department without its effects on the others being considered. If any policy is proposed in purchasing, production, or advertising, which may bring overwork for a period and then lay-offs, the labor manager is present to point out the effect on the workers in the plant and thus have the policy changed to prevent disorganization of the labor force. So it is with every other policy affecting labor. In such a plan as this the personal organization and the industrial relations machinery are directed by the one labor manager. The handling of the personnel problems and the industrial relations are, however, organized separately.

The exact nature of the authority and responsibility placed upon the various agencies dealing with labor in a plant must depend upon the size of the plant, the kind of business, the traditions of the management and the character of the workers employed. No one form of organization will apply to all businesses. The working conditions service of the United States Department of Labor may be called upon to make a survey of health, safety and labor relations in any plant and it will send expert industrial counselors to advise the management as to the best methods and policies of organizing and dealing with labor relations.

Operating the Labor Administration Machinery.

If the management of a business is to perform its employment function properly, it must provide a suitable employment office. Intelligent hiring, proper selection and business like adjustment of difficulties cannot be achieved if this work is done in a noisy and busy factory, in a hallway or outside the plant at the gate or in an alley. An office big enough to provide a waiting room with seats for all applicants for employment and private interviews for each applicant is essential. This office must be so located as to be easily accessible not only to applicants from outside the plant, but also to employes from within the plant and to the company's accounting department. A poor place to hire means a poor place to work to the applicant. To attract good workers to a plant, the employment office must be made inviting, dignified and pleasant.

Next after this must come an intelligent study of the sources of supply of the kind of labor employed in the plant. Promiscuous advertising for labor in newspapers is as wasteful and inefficient as such advertising by a purchasing agent would be who wanted to buy materials or machinery for the plant. The purchasing department goes to definite markets for the things it needs. The employment department must pursue a similar policy. Recommendations from workers within the plant is one of the best sources of labor supply. A prospect file of selected names from those who have applied for work at the plant and those who have quit with good records is another excellent way to get new help.

Systematically ascertaining the labor needs of the plant from time to time is as important as systematic recruiting. This can be accomplished by requiring each foreman or head of a department to send a written requisition for help to the employment department in the same way that requisitions for materials are sent to the storeroom. The foremen is required to give a detailed description of the exact kind of work,

(Continued on page 410)

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Color Detection for Overheated Bearings

Warning of Overheated Bearings or Shafts Given by Painting Chemical Compound on Surface to Be Observed Which Changes Color if Temperature of Bearing Surface Reaches Danger Point.

It is obvious that if warning could be given as soon as heating up of bearings occurred, but before it became serious, much trouble and expense could be avoided and the matter could be rectified in time. Double iodides have been found to possess the property of undergoing a reversible transition involving change of color when heated and subsequently cooled. With most of them the change is comparatively slow, and the transition is so gradual and spread over so large a range of temperature as to be unsuitable for the purposes required.

Two compounds were, however, eventually prepared which gave promise of considerable utility. The first of these was the double iodide of silver and mercury, $AgI.HgI_2$, which is a pale lemon yellow powder at ordinary temperatures, and changes to a vivid carmine color at about 90 degrees—100 degrees C. the change in both directions being fairly sharp. The other was the copper mercuric iodide, $Cu_2I_2.2HgI_2$, which Tonner described. This substance is a very vivid scarlet vermilion at ordinary temperatures and at 60 degrees—70 degrees C. it changes to a chocolate brown. Both these compounds are adapted for use under suitable conditions, but it was found that a mixture of the two, consisting of 85 per cent of the copper salt and 15 per cent of the silver salt, was more sensitive and gave a greater color range from vermilion to almost black, the transition being exceedingly sharp. (Other mixtures were prepared for special conditions, but the above was more generally applicable.)

The compounds may be prepared in a variety of ways; for instance, a very simple method of preparing the copper salt is by well triturating in a mortar 380 grams of cuprous iodide with 910 grams of mercuric iodide, sufficient water being added to form a paste. When thoroughly mixed, the mass is dried in the water oven, and the dried mass ground to an impalpable powder. Another method is to dissolve the mercuric iodide in excess of potassium iodide solution and precipitate the double salt by the addition of copper sulphate solution. The silver salt can be prepared in a similar manner by double precipitation. Whichever method is adopted, the product should be well washed to eliminate soluble impurities, as these appear to retard the color change, as well as to affect its character.

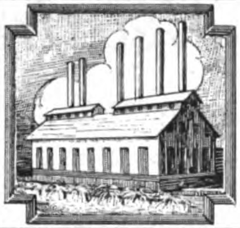
Having prepared the double salts and mixed them in the proper proportion, the means of applying them arises. It has been found convenient to convert them into a varnish-paint or enamel, by incorporating the powder with a colorless varnish medium that will stand moderately high temperatures without softening. A good shellac spirit varnish such as is used on electrical machinery has been found suitable for most occasions, as this will stand a low stoving temperature, but for more elevated temperatures, a medium such as is used in the high temperature aluminium paints used for steam pipes, etc., and which will resist temperatures up to 200 degrees C. is excellent. About 100 grams of compound to 70 c.c. of medium will be found a mixture of suitable consistency.

A convenient method of applying this heat detector is first to paint a white circle or ring on the bearing or other place which it is desired to keep under observation, using a zinc white paint. This white circle is applied to the journal or housing of the bearing, and the detector paint is applied as a vivid red bull's eye in the middle of this, thus forming a very striking object which is visible from considerable distances. It must of course be applied to the block of metal as near as possible to the point at which the heat is likely to be generated. It is sometimes desirable to apply the paint to the shaft itself, just where it extends beyond the bearing metal, and in this case, a convenient method is to apply a broad band of white paint with a narrower band of the red detector paint in the center. This red band in the center of the white one is then easily seen as the shaft rotates. In any case, after the paint is dry, it should be protected with a coat of colorless oilproof varnish, so that the surface may be occasionally wiped free from dust and dirt.

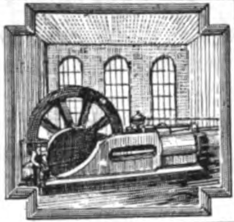
The visibility of the paint against its white background is very high, the bright scarlet color being visible from long distances without effort, and the change at 60 degrees—70 degrees to black is very easily observed, the visibility of the black on the white ground being very much lower. It is generally easy to arrange matters so that the detector is placed in a position where it is visible almost without conscious effort; and experience has proved that a workman is easily trained to cast his eye occasionally on the detector, while he could not be depended upon to climb up to the spot and feel the bearing on the remote chance of finding it heating up. When the paint changes color, there is certainly something wrong, but generally speaking, it will be found that the matter is taken in time, and that no damage is done, the bearing simply requiring cleaning and adjustment without serious stoppage and expense.

This detector has also been successfully used on a gas engine, one of the main bearings of which was frequently heating up, owing to a slightly distorted shaft, and it was possible to place good big "bull's eyes" upon it, which on many occasions gave warning of impending trouble, enabling the load to be reduced.

Abstract from the Journal of the Society of Chemical Industry.



STEAM POWER DEPARTMENT



Combustion Control in Mill Boiler Plant

Flue Gas Analysis—Factors to Be Considered Are Firing, Draft for Thickness of Fire, the Setting, Secondary Air Supply and Furnace Construction.

By ROBERT JUNE,
Mechanical Engineer.

PART III.

In our two previous articles we discussed the various losses occurring in the boiler furnace and setting, and various means for their detection and elimination. We now come to the most important element in combustion control—flue gas analysis.

The Why of Flue Gas Analysis.

The products of combustion, resulting from complete oxidation of coal, with theoretical air supply, consist chiefly of water vapor and sulphur dioxide. With deficient air supply, the flue gases are found to contain carbon monoxide and varying amounts of free hydrocarbon. Excess air results in the presence of free oxygen in the gases. Evidently an analysis of the flue gases offers a basis for judging the efficiency of combustion.

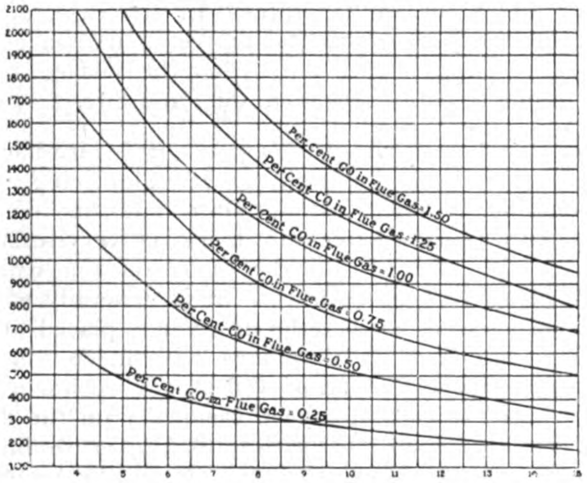


Fig. 1—Loss due to unconsumed carbon contained in the CO in the flue gases.

The following are the things to be studied and adjusted:

1. The firing and handling of the fire.
   (a) Selection of proper firing method for the coal in use (cooking or spreading methods).
   (b) The proper leveling of the fire to keep it free from air holes.
   (c) The proper depth of fire.
2. The draft for the thickness of the fire and the load.
3. The setting, which should be free from cracks.
4. The secondary air supply, which must be provided to complete combustion.
5. The furnace construction.

If the gas analysis is to have any value, the sample on which it is based must be as nearly an average as it is possible to obtain. There is diversity of opinion as to the best method of obtaining the sample. The Bureau of Mines recommends a water cooled tube or a quartz tube as preferable to a metal tube. The A. S. M. E. test code recommends a plain perforated ¼-inch pipe. As between the two the Bureau of Mines recommendation would seem preferable.

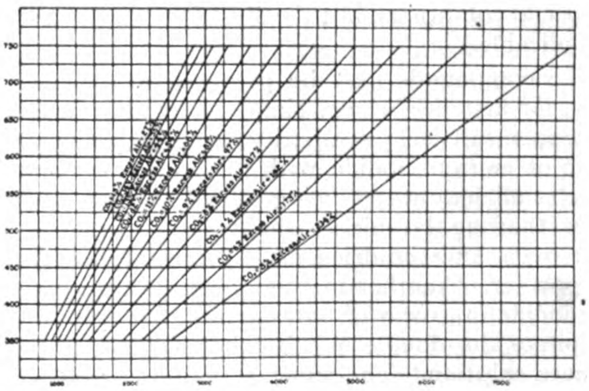


Fig. 2—Loss due to heat carried away by chimney gases, for varying percentages of CO_2

The use to be made of gas analysis determines the location of the sampling tube. If the total heat losses are the desired data, the sample should include all air leakage into the setting. If this information is to be used in controlling the fire, the sample should be taken at some point before the gases are diluted by leakage through the setting.

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Remember the boiler damper in placing the sampling tube, so that the tube is not placed in a gas pocket. Particular attention must be paid to preventing air leakage around the sampling pipe which might give a false indication of the composition of the gases. In a B. & W. boiler, the sampling pipes can be thrust through the top blow-hole in the last pass. In a Heine boiler, the pipes can be run through one of the hollow stay bolts. In return tubular boilers, the top handle can be removed from the boiler doors. Place the tube six inches from the boiler head and above the top row of tubes. If it is put in too far, it may come into a dead space. Be sure to get none of the air leakage around the doors. If air leaks in at the rear arch, most of it will find its way through the upper tubes.

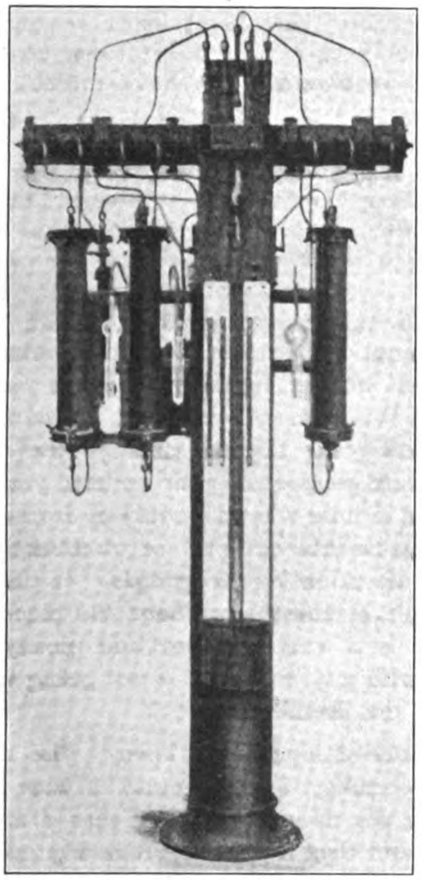


Fig. 4—The Uehling continuous CO_2 recorder.

The Orsat apparatus recommended by the Bureau of Mines for CO_2 determination is shown in Fig. 3. It can be purchased either in the form shown or in a modified form, from a number of reliable manufacturers. Full directions for its operation are given in the Bureau of Mines bulletins, or may be obtained from the manufacturers.

While hand indicators, such as the Orsat, can be used as a means of studying air supply conditions or for occasional tests, they do not answer the purposes of daily plant operation, since the CO_2 content of the flue gases may, and does, vary widely, rapidly and continuously, due to the fact that the proportions of the air supply which come through the fire and in above the fire, are easily upset by throwing on of fresh coal, the burning through of thin spots, accumulations of clinker and ash, manipulation of dampers and firedoors, etc. It can hardly be said that CO_2 recorders act promptly enough to follow the variations in CO_2, from minute to minute, but they do, on the other hand, produce a chart showing an average, which serves as a warning to the fireman who is careless or incompetent in his management of the fire and draft.

Remember that while CO_2 indicates a small amount of excess air, it does not necessarily mean correspondingly good combustion.

Low CO_2 may be caused by excess air, insufficient air (high CO), or improper mixtures of the air and gases, but a surplus of air is the cause in almost every case. The difference between the CO_2 percentages in the last and first passes indicates the air leakage in the setting.

CO_2 is affected by the character of the fuel. The more hydrogen in the coal, the less CO_2 in the flue gases. If the fuel were all carbon, there would be 21 per cent CO_2. If all hydrogen, there would be no CO_2 in the setting.

We must not attempt, however, to secure high CO_2 by cutting down the draft only. High CO_2 can be obtained with any draft in reason, either high or low, provided the draft and the fuel resistance are in proper relation. CO_2 percentage indicates the ratio of air used to the air that has not been used. It is sometimes feared that 8 or 10 per cent CO_2 cannot be obtained without CO in considerable quantities. This is not in accordance with general experience. There is little danger from CO until about 15 per cent CO_2 is reached.

The percentage of CO_2 is the index of the amount of heat being wasted up the stack. It is little realized how large a return will result from a small increase of average per cent CO_2. The chart of Fig. 3 (page 350, July issue) shows, for instance, the dollars saved per 100 bhp that is operating 365 days per year, 24 hours per day, for various prices of coal, and corresponding to an increase in CO_2 from any original figure to any final figure. Suppose, for instance, that the original value of CO_2 is 7 per cent, and that after equipment with CO_2 recorder, the average CO_2 is increased to only 8 per cent. Starting at the 7 per cent mark of the horizontal line of this chart and rising to the 8 per cent curve and then running over horizontally to the left, we find that with coal at $4 this increase of CO_2 means a yearly saving of $375. This, of course, is for 100 bhp operating continuously. If the load-factor instead of being 100 per cent were only 25 per cent, the saving would be one-quarter of $375, or $94 per 100 bhp, and for a 500 bhp, 5 times $94 equals $470.

The CO_2 indication answers most practical purposes. If greater certainty is desired after the CO_2 has been brought up to the desired percentage, the CO determination can be made. The formation is due to:

1. Furnaces of poor design.
2. Improper methods of firing.
3. Character of fuel, particularly with reference to the equipment with which it is burned.

4. Improper mixing of combustible gases with the air.
5. Low furnace temperature, so that the gases are cooled below the ignition point.
6. Deficient air supply.

The formation of CO is usually due to insufficient air supply, which, as pointed out by the Bureau of Mines, may be either local or general. Either the local or general causes may be from the composition of the coal. The coal may be fusible, in which case the surface of the fuel forms one solid layer of semi-liquid fuel, which effectively stops the passage of air. At the same time, a large excess of air may be fed into the furnace elsewhere. The same local excess or insufficient air supply may be caused by the fusion of ash on the grates. The volatile matter may be driven off so rapidly after a fresh charge of coal that the average air supply is not sufficient, whereas a couple of minutes after firing, it is too large.

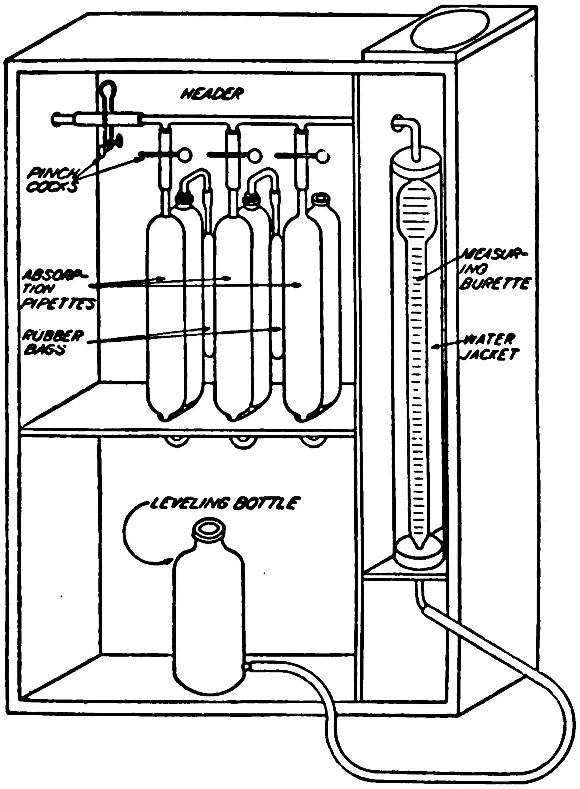


Fig. 3—The Orsat apparatus for determining percentage of CO_2 in individual samples of flue gases.

The occurrence of CO_2 in the waste gases is a decided danger signal, not so much on account of the loss which it represents, but because it is usually accompanied by unconsumed hydrogen and hydrocarbons.

Flue Gas Temperatures and Efficiency.

Flue gas temperatures should be taken with a continuous instrument. They serve a number of useful purposes.

1. Call attention to leaks in boiler setting. In case air is allowed to leak into the flues and mingle with the gases after they have left the heating surfaces, the temperatures may be brought down to almost any point above that of the atmosphere, but without any reduction in the amount of heat wasted.

2. Indicate condition of furnace and boiler, such as:

(a) Dirty fire.
(b) Holes in fire.
(c) Presence of scale on water surfaces.
(d) Presence of soot on fire surfaces.
(e) Faulty condition of baffles.

Of the conditions just mentioned, unclean heating surfaces are most important, since they are most prevalent and constant. Many cases are on record where continuous soot removal, such as is obtained by the use of mechanical soot blowers, has affected a continued reduction in flue gas temperatures of 80 degrees F.

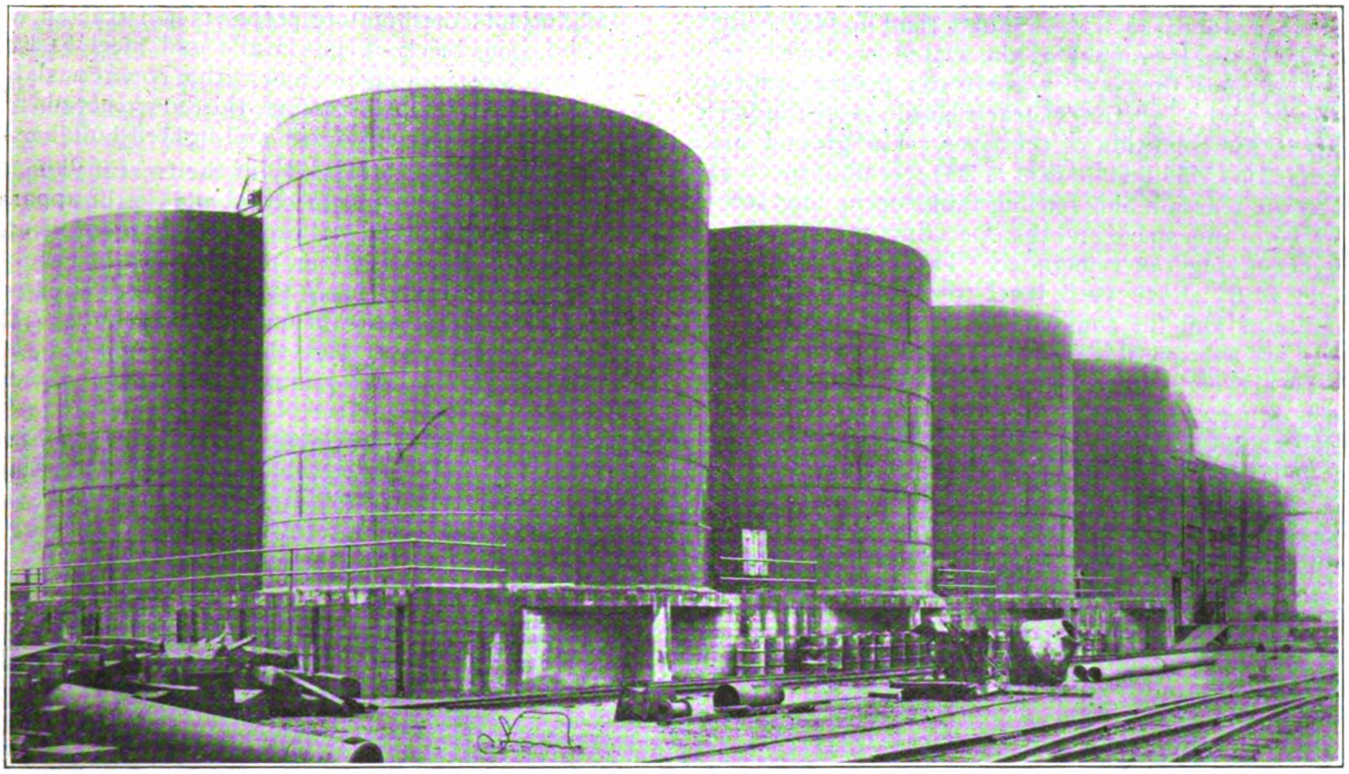
In conclusion, there is no more reason why you should ask or permit your boiler room crew to work without the instruments we have discussed than to permit them to work without a pressure gauge. Instruments tell your men where they are at. Given knowledge and good intention, they will soon improve operating conditions. At present, the state insists upon the pressure gauge. The time is rapidly approaching when it will insist upon the other instruments.

In concluding the discussion of draft, and draft gauges I cannot do better than quote a statement once made by that master engineer of boiler room operation, Joseph W. Hays: "Visit your boiler room today and note how your firemen manage the drafts. If there are draft gauges on your boilers, you will first be interested to note what a variety of drafts you have. You will also be interested to see whether the firemen are paying attention to the gauges. If they do not, it is the fault of somebody about the place—not the firemen. It is a waste of time and money to equip your plant with anything that is not going to be used. Now watch the firemen.

"The boiler dampers are open. The damper in the main breeching, if there is one, is wide open also. The firemen act upon the theory that draft is made to be used, and that if some draft is a good thing, all of the draft that can be obtained must be better. They take the whole box of pills at one dose.

"The rule, when designing a power plant, is to provide for an excess of draft. Dampers are furnished in order that the draft may be under control. The boiler damper has the same relation to the furnace that the throttle bears to the steam engine. The firemen should set the dampers to give the draft that is called for—no more and no less. The dampers should never be wide open except under the most extreme conditions of load.

You will notice, most likly, that the firemen use the ash-pit doors to check the draft when the steam approaches the popping point. They have discovered that this is a very effective way to quiet the enthusiasm of the boiler. They do not know that it is the wasteful and improper way."



Exterior view of water tanks at plant which has a treating capacity of 300,000 gallons per hour.

Feed Water Treating and Purifying Plant

Water Softening and Purification Plant Built by the W. B. Scaife Company Supplies Feed Water for Five Plants at Republic Iron & Steel Company, at Youngstown, Ohio.

By S. H. McKEE.
Assistant Chief Engineer, Republic Iron & Steel Co.

The Republic Iron & Steel Co. has installed a water softening and purification plant to supply feed water for the boilers of the five plants of the company, located along the Mahoning River.

The plant as installed has a treating capacity of 300,000 gallons per hour and it is so laid out that a 25 per cent extension can be made, to give an ultimate treating capacity of 375,000 gallons per hour, which will safely meet any future demands that might be made on this plant. The capacity of the plant, as installed, is very liberal, using the present requirements as a basis, but it was felt that this was justified, particularly on account of its importance, in that the plants are dependent entirely upon this source of supply for a good and sufficient feed water for the boilers, although, as a safety measure, the feed water heaters are connected to the general service lines at the various works, this supply of raw water coming into action automatically if any serious stoppage in the supply of treated water should occur.

A two-compartment intake was built on the river bank, each compartment was provided with stationary and motor-driven traveling screens and with sluice gate valves operated from yard level, to enable each compartment of the intake to be cut off from river connection. Each compartment is of ample capacity to take care of the maximum ultimate requirements of the water softening plant. Concrete tunnels connecting each section of intake with a separate pump well under pump room in softening plant were built. These tunnels are of sufficient cross section to allow for proper cleaning and a manhole is provided for ready access to tunnels that any accumulations may be easily removed.

The sewage from the city and wastes from all manufacturing plants above Youngstown, extending up as far as Warren, O., are discharged into the river and the impurities thus introduced, in addition to the suspended matter and the hardened water in its normal condition, makes it an undesirable feed water supply without purification where high rates of evaporation are to be maintained.

It was decided to install a cold process system of the intermittent type to take care of the conditions, be-

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From paper read before Engineers Society of Western **Pennsylvania.**

cause of the demonstrated efficiency in treating Mahoning river water, as it was found that in this system, in which the treatment of the water is carried on in fixed volumes, the result was a water that is uniformly softened and at all times clear regardless of the variations in the condition of the river. The ground space occupied by this installation is 260 feet long by 79 feet wide, the reaction and settling tanks occupying 166′ 0″ x 79′ 0″ of this space and the operating and filter building occupying the remainder. The entire foundation is set 7′ 6″ above yard level to guard against flood conditions and the foundations for both building and tanks are thoroughly waterproofed to prevent leakage. There are eight reaction and settling tanks built of steel, 37 feet in diameter by 35 feet high, arranged in two parallel rows at 40 feet centers with four tanks per row. Stairways and platforms are provided to allow ready access to the top of the tanks with tunnels and passage ways in foundations underneath the tanks to house the filling and delivery piping and operating mechanisms, all being easily accessible for inspection and repair purposes.

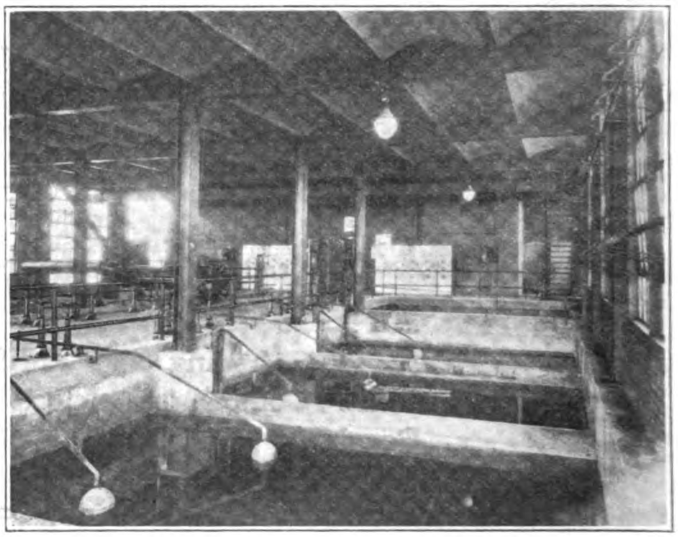
The pump room is located in the operating and filter house in the end of building towards reaction and settling tanks. This building is 94 feet long and 62 feet wide, two stories high above foundation level. Below ground level at a distance of 12′ 6″ is located the base of the pump room which is 58′x36′. In the end of building away from reaction and settling tanks located below ground level is the purified water basin or clear well which is 58′ 0″x52′ 6″x14′ 0″ deep, holding 295,000 gallons of water.

Over the clear well are the filter units, eight in number 20′ 0″ long by 12′ 6″ wide and 9′ 3″ deep, arranged in two rows of four each, between which is a pipe gallery 12′ 0″ wide with a headroom of 8′ 10″, the floor of this gallery being at the same elevation as the bottom of the filters. The pipe gallery is floored over at the same elevation as the top of the filters. At the end of the filters and clear well this floor is extended across the basement, which contains the pumps. A portion of the floor immediately over the pump is cut out, to provide light and ventilation. This same floor level, or first floor, is the main operating floor of the purifying apparatus. On it are located the panels on which are mounted the control devices of the hydraulic valves and the alarm bells and switches for motors. There are also on this floor the recording gauges, the sample line faucets and basins, the apparatus for testing the samples of water, and the valve stem extension stands for the operation of the filter valves. On this same floor level, or first floor, there is a separate dustproof room, 42′ 0″ long and 10′ 0″ wide, by 14′ 0″ high, in which are installed six reagent mixing tanks. In this room the charges of reagents for treating the water are made up and from here delivered to the reaction and settling tanks.

The second floor of the pump and filter house is used for the storage of chemicals and for weighing out the charges required for treatment. This floor is reached by an elevator that has an outside entrance onto an unloading platform 3′ 6″ above ground level and served by a standard gauge railroad track.

Stairways are provided connecting all floors of the building and the building proper is constructed with a steel frame, brick curtain walls and steel sash with reinforced concrete floors and with a concrete slab roof covered with built-up roofing, this construction resulting in a very attractive and well lighted building.

Inasmuch as the capacity of the treating apparatus was based on the operation of the settling tanks in pairs, each pair having a capacity to provide water at the rate of 300,000 gallons per hour for one and two-third hours on the basis that water is delivered for filling a pair of tanks in one hour, or at the rate of 500,000 gallons per hour, there was supplied to perform this service, two pumping units, each capable of delivering 10,000 gallons of water per minute against a 70-foot head. Each unit consists of a horizontal single stage double suction centrifugal pump driven through reduction gears by a condensing steam turbine and each unit is of ample size to meet the ultimate demands of future requirements.



Interior view showing filter units.

It will be noted that there has been provided a dual installation of intake, tunnels, wells, etc., to supply these pumps with the necessary water, and each system can be cut off at will and cleaned as the remaining system is of ample size to take care of all requirements.

The raw water from the supply pumps is delivered to the reaction and settling tanks through a 20″ main, from which 14″ connections are made to each of the tanks.

These pipe connections are through the bottoms of the tanks. Each tank connection is provided with a branch, which is connected up with a sewer line. The valves in both the filling and the sewer connections are hydraulically-operated, with an emergency shut-off valve between the hydraulic valve in the filling line and the water main. Any tank or pair of tanks can be isolated, if necessary.

Each tank is equipped with a mechanical stirring device, operated by an individual direct-connected electric motor. The stirring device shafting passes up

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through the bottom of the tanks through a stuffing box.

Each tank is provided with two float-operated electric alarms with bells located in the operating house. Each tank is also equipped with a recording altitude gauge, which registers the time required for filling a tank, the time the tank is settling and the time in which it is emptied, the time consumed in washing filters and amount of water so used, the charts of these gauges giving an accurate record of the treatment cycle of each tank.

The water after being treated and settled is drawn from the tanks through a floating outlet pipe 14" in diameter that takes the water from the top and follows the descending level until a stop carried on the pipe rests on the bottom of the tank, holding the pipe at a fixed elevation to insure a uniform emptying depth and to avoid running sludge to the filters.

These floating outlet pipes are connected to the bottoms of the tanks through a special form of flanged elbow that permits the pipe to move in a vertical plane, but prevents movement in a horizontal plane. These floating outlet pipes are connected into an 18" main. Each connection is provided with an hydraulically-operated valve and, in addition, there is an emergency shut-off valve between the main and the hydraulically-operated valves. The main is carried to the filters, where it is divided into two lines, each supplying four filter units.

The controls, reagent mixing tanks, etc., are located in operating and filter house on operating floor.

The controls for each reaction tank are mounted on individual marble panels and these different panels are assembled in two rows of four panels each similar to a switchboard. Each panel has a recording altitude gauge, three control handles connected to 4-way cocks for inlet, sewer and outlet valves to and from reaction tanks, a push-button motor starter for stirring device and a switch for the high water alarm. At the end of each row of operating panels there is a panel fitted with a two-pen recording thermometer indicating temperature of the incoming and outgoing water, also an indicating pressure gauge for the hydraulic system, a discharge line recorder and four sample bibs mounted over a sink. These sample bibs are connected with 1" lines to the different reaction tanks for drawing samples of the treated water for testing.

Pressure for operating all hydraulic valves is obtained from a pair of duplex steam pumps located in pump room of building, one of these pumps being a spare. The water lubricated by soap in solution is drawn from a sump, then forced by the pumps through a pneumatic water supply tank into a main from which connections are made to four-way cocks controlling the different hydraulically-operated valves. The pressure used is 70 pounds.

Interior view of operating and filter house. Control panels seen in the rear.

Six reagent mixing tanks are provided in two rows of three tanks each, so that three different reagents can be prepared simultaneously for making treatment in two reaction tanks at the same time. These reagent mixing tanks are fitted with motor-driven stirring devices with silent chain drive and friction clutches. The charges of reagents are weighed out on the storage floor and then dumped into hoppers which are hung through the floor. The hoppers have an outlet gate at the lower end, through which the chemicals are allowed to fall into the reagent mixing tanks.

In the pump room under the reagent mixing tank room there are three centrifugal pumps for delivering reagent solutions to the reaction tanks. These three pumps are located and connected in such a way that the third pump is a spare for use with either row of reagent tanks.

The discharge piping from the reagent pumps is arranged so that each pump supplies four reaction tanks. The suction and discharge connections to the pumps are arranged so that the reagents from any one of the three reagent mixing tanks can be pumped to any of the four reaction tanks.

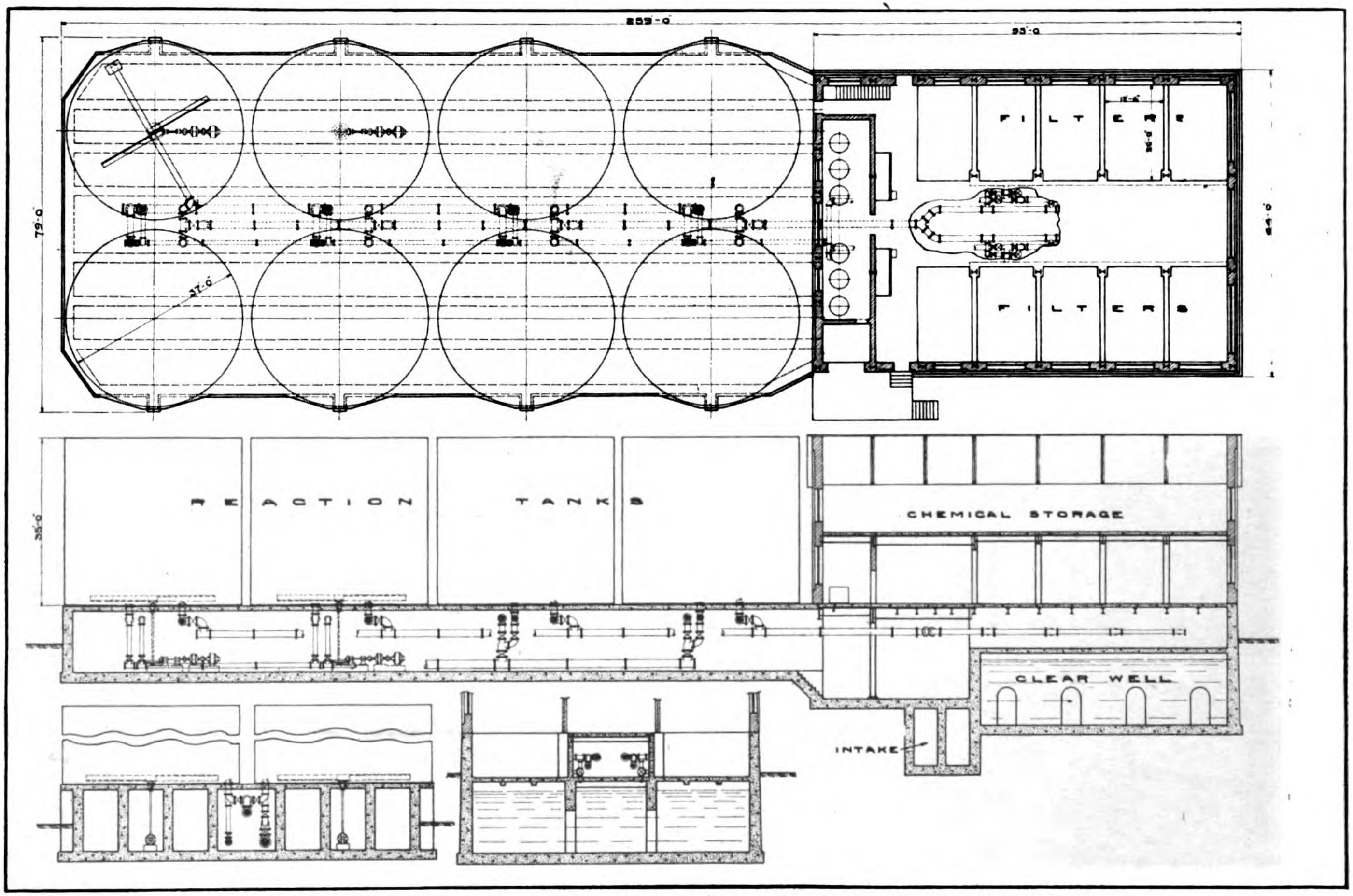
The delivery of water from the reaction and settling tanks to each filter is controlled by a double-disc balanced valve, operated with a float in the filter. The outlet from the filters is discharged into the purified water basin immediately under the filters and under the pipe gallery. This basin is equipped with an indicator to show water level and also equipped with a recording altitude gauge to show the water level at any period of the day.

The arrangement of the pipe connections to the filter units are such that any or all of the filters can be operated with any or all of the reaction and settling tanks discharging water through the floating outlet pipes.

The filters are equipped with special form of brass strainers screwed into a manifold, with the strainers uniformly distributed over the area of the filters, approximately 7½" center to center.

The filters are also equipped with an individual airwash system consisting of ¾" brass laterals, iron pipe size, drilled for a uniform distribution of air. This air piping is placed immediately above the strainer piping in the filter bed.

Air is supplied from a direct-connected motor-driven positive blower located in the pump room.



Plan and elevation showing general arrangement of reaction tanks, filters, chemical storage, etc.

The treatment of the water is carried out as follows:

The charges of lime, ferrous sulphate and soda ash are weighed out and put into the reagent mixing tanks. The lime is slaked so as to be ready to be introduced into the reaction and settling tank when the filling of the tank begins. As soon as the filling of a reaction and settling tank begins the charge of lime is pumped into the tank and the stirring device in it is started. The stirring device is kept in operation during the entire period of filling the tank and no other reagents are introduced until the tank is full, the filling time being one hour. When the tank is full, the charge of ferrous sulphate is introduced and 10 minutes afterwards the sample of water for testing the correctness of the treatment with lime and ferrous sulphate is obtained.

Following the introduction and mixing of the ferrous sulphate the charge of soda ash is introduced and the stirring continued for 15 minutes thereafter. The stirring device is then stopped and the water allowed to stand quiescent for reaction and settling. Thirty minutes after the stirring is stopped a sample of the fully treated water is drawn for testing. At the end of the settling period, the water is delivered to the filters as required.

The floating outlet pipe is flushed into an empty tank before turning the water into the filters. This washes out the sludge that has accumulated in it and prevents the fouling of the filters.

The floating outlet pipe draws off the clearest water from the top of the settling tank and follows the drop of the water level. The precipitates settle out of the water ahead of the pipe, so that there is only a minimum of sludge carried to the filters. The stop on the pipe prevents it from reaching a position where settled sludge will be carried to the filters. The softened and settled water after passing through the filters is delivered into the clear well.

The rate of flow of the softened water from the settling tanks to the filters is controlled by the position of the water level in the clear well and with the clear well full the inlet valves on the filter automatically operate to hold back the water in the settling tank.

The clear well acts as a balancing tank between the demand for water and the supply coming from the reaction and settling tanks. When the demand for the water exceeds the capacity of the equipment, extra water is supplied from the clear well.

The function of the filter is to remove the crystalline precipitate that is too fine to settle and to guard against the possibility of dirty water from the settling tanks from any cause getting into the boiler feed system.

The equipment is designed to operate two reaction and settling tanks simultaneously and with the four pairs of tanks the alternate filling and emptying of a pair maintains a constant supply of water.

The interval for settling, together with the volume of water held by the purified water basin, or clear well, gives sufficient time to treat correctly all of the water used.

Two pumps were installed to deliver treated water from clear well to the various plants, each capable of pumping 5,000 gallons of water per minute, against a 145 foot total head. Each unit consists of a horizontal single stage double suction centrifugal pump driven through reduction gears by a condensing steam turbine and each unit has sufficient capacity to meet any future demands, although it was deemed advisable to provide room for the installation of an additional pumping unit. Under average conditions it required a total head of 137 feet to deliver the necessary quantity of water to the Bessemer and Brown-Bonnell plant through the 16" pipe that was in place, but under peak conditions at this plant it requires a total head of 245 feet to supply the necessary quantity of water. The maximum total head required to deliver the necessary quantity of water at the other plants was 127 feet. A pumping unit capable of delivering the quantity of water required at peak conditions of 245 feet head at the Bessemer and Brown-Bonnell plant would necessitate a two-stage centrifugal pump with a turbine of sufficient size to take care of this load. A careful investigation of the peak conditions over a considerable period of time disclosed that the maximum length of duration was 12 minutes. The solution of this problem was to build a storage make-up tank of 20,000 gallons capacity, set adjacent to the feed water heaters at the Bessemer and Brown-Bonnell plant and placed at a sufficient elevation to deliver water to feed heaters by gravity. It required a total head of 134 feet to fill this tank, but, in order to be on the safe side, pumps were installed to work against 145 foot head, using single stage centrifugal pumps. This tank is under control of a motor-operated valve set in the vertical supply line, which is controlled by the pressure under the valve; should this pressure drop, due to the occurrence of peak conditions, the motor automatically opens valve and the necessary make-up water held in storage is supplied the feed heaters. This valve remains open until such a time as the water requirements decrease and the tank is filled, when the valve is automatically closed by the building up of pressure in the supply line.

The supply and delivery pumps are steam-turbine-driven, and in connection with these units a water works type of condenser was installed in the pump pit of the water softening building proper. The treated water is used for condensing purposes as there was a much larger quantity at all times than necessary for this purpose and it was a very simple matter to pass the water through the condenser on its way to being delivered to the various plants. A by-pass is provided for passing the treated water around the condenser, should this become necessary. A master Venturi meter for check purposes is provided in the main delivery line just outside of the water softening building proper.

Analyses of the Mahoning River before softening and purification with analyses of the water after being softened, shows in the softened water the absence of the sulphates, chlorides, and nitrates of lime, iron and magnesia, also the total of the residual lime as calcium carbonate and the residual magnesia as magnesium hydroxide is less than 2.0 grains per gallon. In addition to the reduction in incrusting solids, the water is free from suspended matter, the turbidity being zero.

With this equipment it is possible to control the treatment of the water and to keep it within any desired limits.

There is a striking contrast in the appearance of the water before being softened and purified and the water as delivered into the clear well, and the system is giving the anticipated results.

FOREIGN RELATIONS

TRANSPORTATION FACTOR OF POST WAR RECONSTRUCTION.

Synopsis of address given at Shanghai, March 22, 1919.

By Paul P. Whitman, U. S. Trade Commissioner.

It is a common and very true saying that the world grows smaller, that it shrinks in size in proportion to the advances made in the adequacy and rapidity of the means of transportation. Geologists tell us that many of the eruptions upheavals and disturbance of the earth's surface resulted from unequal shrinkage pressures. May it not be true also that many of the human disturbances of the world are due to the inequality of shrinkage of the size of the earth resulting from highly developed transportation facilities in some portions while other sections remain stagnant

Story of Yunnan.

A little over a year ago when in Yunnanfu I attended a dinner given by some Chinese students. They asked me many questions about America. One chap asked how large is America. I replied nearly as large as China including the outer territories. How long does it take to cross America, he then inquired. Reply was about five days. Well! he said, there must be some mistake, America cannot be as large as Yunnan Province which requires 30 days to cross. This young Chinese was right. As a result of rapid transportation facilities, America has shrunken in size until it is smaller than the Province of Yunnan.

The big minds of the Allied countries are concerned with the reconstruction problems especially in the European war zones. Some of the far seeing are also giving thought to the general world reconstruction problems that must be met if civilization is to advance and make secure the new ideals born of the war. It would be seen that transportation development is a most important factor of any world reconstruction program. Economically the world requires access to the resources of the unused and backward countries of the earth.

From the humanitarian standpoint the people in these unused and backward places need to be brought into touch with life currents of the more advanced countries. If the principles for which the war was fought and won are to spread, if democracy is to prevail the world must be knit together, must be made small evenly by the universal extension of adequate and rapid means of communication. If you will study the map of the world you will discover that a surprisingly small portion of the land surface of the earth is adequately if at all provided with modern means of transportation. Europe and a portion of North America is about all that is so equipped and even the countries most advanced in that respect are taking steps to extend and better their facilities.

The great continent of Asia, most of Africa, and much of South America present nearly virgin fields for transportation development. To adequately meet the needs of these continents is a tremendous task that may well stagger the financial resources and the constructive ability of the Allied nations. But unprecedented things have been accomplished during the war and it will be necessary to carry on with a world development program on a scale that would have been considered impossible in pre-war days. Only by doing so can the burden of the great war debts be lightened.

The Chinese and we foreigners in China naturally are most interested in the application of the thought of Asia. Only the fringe of the Asian continent has been touched. In the great central regions are vast potential resources. There are grazing plains larger than any of the countries of Europe. There are tillable valleys, extensive forests and mineralized mountains, in which are locked up potential resources and dormant productive areas of which the world is in need. At present they are inaccessable on account of lack of transportation. Illustrating this, a few weeks I was at the railhead of a line pointing westward but scarcely started across China's 3,000 miles. This railway follows one of the great caravan highways that runs westward into the heart of Asia, in fact across the continent. Over this primitive trail goods were being transported to and from the railhead in carts and wheelbarrows, on pack animals and men's backs. So thick was the traffic that standing on a mountain top it had the appearance of an endless chain conveyor. But how slow it moved and what small units were carried. Inquiry developed the fact that on that particular mountainous section it cost from 30 to 40 cents per ton mile for transportation. The railway took the goods away for approximately 3 cents per ton mile and that is a high rail rate.

Inspection of the commodities carried revealed that they were either of high value per weight unit or necessities required at most any cost. The products of Central Asia that dribble out in this manner of necessity under such conditions are infinitesimal as compared with the potentialities of the country.

A few months ago I made a trip across a portion of Mongolia from Kalgan to Urga, about 700 miles. There may be deserts in Mongolia but the section I traversed is a grazing country comparable to the cattle country of Wyoming and Montana. Recently the Chinese have been breaking sections of it into cultivation and are able to produce hardy grains and vegetables. What is generally known as inner and outer Mongolia was a combined area approximately the size of the United States easterly of the Mississippi or all of Western Europe. To be conservative say only half of it is usable. Yet there is a great potential cattle country much farming land and near the Siberian border extensive forests.

The world's sources of meat supplies are running short. In North America the cattle country is being broken up into farms. The world may need to use Mongolia as a source of a new supply. It must be made accessable by better means of transportation. A railway across Mongolia would also tap Central Asia outside of China and serve as a transcontinental line to Europe. This is another illustration, of which there are many, of the need of transportation and serves to indicate the magnitude of the task.

The Chinese have a great deal at stake in the proper transportational development of Asia. China is remarkably well situated geographically relative to the continent. The Himalayian mountains and the high Tibetan plateau acts as a barrier cutting off Central Asia from direct access to the Indian seas consequently the transcontinental routes must pass northerly of Tibet through outer China. China possesses the chief Pacific frontage so that much of the traffic from Central Asia and portions of Siberia is bound to seek an outlet through Chinese ports if adequate carrying facilities are provided. This is an added incentive to a proper transportational development in China if the Chinese own needs be not sufficient. However to take advantage of the situation China must first look after the development within her own borders. Outside capital will be required as it was in North America. The world has enough at stake in the development of the people and resources of Asia to justify the leading financial countries coming forward with the money to the extent of their ability consistant with needs elsewhere.

There may be room for keen and healthy trades competition in many lines but in supplying the world's transportation needs there is a splendid opportunity for international

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coöperation. There will be sufficient opportunity for all. Money will be required faster than the surplus capital of all the nations becomes available. Such coöperation will be feasible in proportion to the extent to which the old idea of commercial domination gives way to the new spirit of constructive mutually beneficial trade promotion which views commercial activities as a form of international intercourse, a give and take, profitable to all parties concerned. This is a big subject that in the brief period available can be indicated only in general outline.

In conclusion permit me to suggest that much of the hope of a lasting peace, of an effective and workable league of nations is dependent upon a prompt and adequate extension of transportation facilities into the unused and backward places in the world. The task is to diminish the world's size evenly throughout its surface in order that mankind may be bound together and the danger of human upheavals may be avoided

COMMERCIAL POSSIBILITIES OF THE PORT OF BREST.

(Translation from La Bretagne Commerciale, May 15, 1919, signed by Lucien Cornet, senator from the Department of l'Yonne and a member of the French finance commission, transmitted by Consul Sample B. Forbus, Brest, France.)

At the extreme western point of France, said Henri Le Verdier, there is a bay isolated from the ocean and protected by a gigantic cliff. In this bay some wharves have been constructed in anticipation of a commercial port to serve as the railhead for great transatlantic lines running between North and South America and Europe. Thus, the situation of Brest is without equal. Brest would be the only European port where a traveler coming from New York could land after a four-day voyage.

But we do not concentrate at all and the steamships go to other ports. This state of affairs has existed for the last 30 years. As far as the French are concerned, everyone agrees upon appreciating Brest, but they go no further. However, the Americans have known how to utilize this marvelous instrument; but the Americans will leave—they are leaving now. The Germans had built up great hopes on Brest and had drawn up extensive plans for the development of its port which we would do well to put into execution.

Naval Advantages of the Port.

It is our turn to look into the possibilities of this valuable road—the largest, deepest, and safest of all harbors on the continent of Europe. It affords a depth of 12.5 meters (41 feet) at low tide over about 500 hectares (1,235.5 acres), or approximately two-fifths of its entire surface. The entrance to this harbor is the famous "Goulet" (Narrow Channel), with a depth of 20 meters (65.6 feet), and the outer approach to the entrance with a depth of 100 meters (328 feet), which enlarges progressively until it has a width of 30 marine miles.

The risk of running aground is nil. The coast about Brest has been gradually equipped with a system of lighthouses, sounding signals, and buoys until it is the most completely protected part of the French coast and has reduced to zero the chances of running aground. Accidents to ships entering or leaving Brest are unknown. Of how many ports is this true? Quite recently these measures of protection have been increased by the installation of Hertzian signals on the islands of Sein and Ouessant which, with the adjustment of the radiogoniometer, has definitely removed all cause for objection to the nautical conditions of access to the harbor of Brest.

The Second Empire caused a commercial port to be constructed at Brest and that port has remained just as it was then established for 50 years. After many insistent demands a dry dock was built between 1903 and 1907, and then enlarged in 1911. But this commercial port, without doubt the only one in France which has cost only a trifle for its upkeep, is perhaps also the only one which has not been developed.

Moreover, nature has done nine-tenths of the work. Close by the existing docks there is a shoal—the Banc de Saint-Marc—the depth of which varies from one to three meters (3.3 to 9.9 feet) at low tide. It is exceptional in this harbor, but at about 1,200 meters (3,936 feet) along the shore the bottom drops away sharply until there is a depth of more than 12 meters (39.4 feet) at the short distance of 200 meters (656 feet) from the shore. There are present here all the requirements for the construction of wharves at low cost which will touch deep water without the necessity of dredging. Along with this favorable Banc de Saint-Marc there is the happy coincidence of a surface soil from 12 to 15 meters (40 to 50 feet) deep composed of compact clay resting on bedrock. There is consequently provided a foundation for docks, without which it would be necessary, in order to make excavations, to undertake the costly work of cutting through bedrock.

If solid rock is required for the foundations of docks, it is present. Should it be a question of digging easily, there is nothing but clay to be removed. As to an anchorage, there would be ample depth all along the docks. Certainly nature has nowhere else been so helpful.

Industrial Possibilities.

It has been said that there are no industries in this region. It is coal from Cardiff that furnishes the energy for Trignac, Basse-Indre, and all other industries of the Nantes group. If coal came by way of Brest it would have a shorter route to cover. Moreover, there is already here a navy shipbuilding plant which is considered one of the best equipped in the world.

But there exists at Brest everything necessary to create a first-class industrial center and to take care of the needs of those who desire to establish themselves in the neighborhood of a great port for the purpose of manufacturing from imported materials. Midway between Brest and the Bay of l'Aberwrach, where Morgan once intended to land his fleet, there is the poor land of Milizac and Bourg-Blanc where an industrial city could be built up at moderate expense. As regards the question of labor, it is abundant. The people would be inexperienced in the beginning but they are tractable and belong to one of the most adaptable and intelligent races of Europe.

METALLURGICAL EXCHANGE IN ZURICH.

Consul General L. J. Keena, Zurich, Switzerland.

The Societe de Valeurs pour Fers et Acier (Society for Values of Iron and Steel) in Schaffhausen, Switzerland, has established in Zurich a metallurgical exchange, the purpose of which is to bring together every Friday buyers and sellers of machines of every description and of all kinds of metals used in the manufacture of machinery.

The exchange solicits the membership of foreign engineers and exporters of raw materials and calls particular notice to the advantages which a foreign member will have in the marketing of his products in Switzerland by visiting the exchange and bringing his business to the attention of manufacturers desiring to import. The fee for such membership is $5 a year.

Further details regarding the exchange will be furnished upon application by interested parties to the above address.

STEEL AND IRON COSTS IN GREAT BRITAIN.

(Consul General W. Stanley Hollis, London.)

The increase in the price of coal to the railways and steamships in Great Britain is causing freight rates on all raw materials to be still further enhanced; the prices of all raw materials are also increased, and, owing to the general rise in the cost of living, the costs of labor have been greatly advance. Thus the prices to the manufacturer of fuels, raw materials, transportation, and labor are very much greater today than in prewar times. The results of these increased costs are very clearly seen by examining the present-day condition of an ordinary mechanical engineering factory, in which, for example, it may be assumed that one horsepower is developed in the power house for each workman employed.

PRODUCTION TOPICS

IRON AND STEEL STATISTICS FOR 1918.

The American Iron and Steel Institute has just issued special statistical bulletin Number 3 for 1919, showing the production of steel ingots and castings, finished forms of rolled iron and steel, and miscellaneous iron and steel products in the United States in 1918.

The majority of the statistics show a decrease in production as compared with 1917, the total production of steel ingots and castings falling off from 45,060,607 in 1917 to 44,462,432 total gross tons in 1918. The production of steel ingots and castings by processes for the last five years is shown in the following table:

	Open hearth							
Yrs.	Basic	Acid	Total	Bessemer	Crucible	Electric	Miscellaneous	Total Gross tons
1914	16,271,129	903,555	17,174,684	6,220,846	89,869	24,009	3,622	23,513,030
1915	22,808,725	1,370,377	23,679,102	8,287,213	113,782	69,412	1,527	32,151,036
1916	29,616,658	1,798,769	31,415,427	11,059,039	129,692	168,918	604	42,773,680
1917	32,087,507	2,061,386	34,148,893	10,479,960	126,716	304,543	495	45,060,607
1918	32,476,571	1,982,820	34,459,391	9,376,236	115,112	511,364	329	44,462,432

It will be noted that open hearth steel showed a slight increase over the previous year due to an increase in basic open hearth. The outstanding feature of this table is the advance made in electric steel production. In 1917 the production of electric steel was 304,543, whereas in 1918 this rose to 511,364 tons, an increase of 67.8 per cent.

The following table shows the production of steel ingots by processes for the last five years. The same general tendencies are noticeable in this table as in the one above:

	Open hearth							
Yrs.	Basic	Acid	Total	Bessemer	Crucible	Electric	Miscellaneous	Total Gross tons
1914	15,936,985	633,382	16,570,367	6,154,964	78,863	15,458	312	22,819,784
1915	21,975,622	968,148	22,943,770	8,194,737	99,026	46,348	331	31,284,212
1916	29,011,146	1,227,832	30,238,978	10,916,248	120,341	126,018	302	41,401,917
1917	31,528,939	1,406,798	32,935,737	10,320,688	122,882	239,632	261	43,619,200
1918	31,970,691	1,347,870	33,318,561	9,215,392	113,782	403,068	219	43,051,022

In 1918, 212 works in 25 states and the District of Columbia made steel ingots, against 202 works in 26 states and the District of Columbia in 1917.

In 1918, 280 works in 30 states, the District of Columbia, and the Canal Zone, Panama, made steel castings, against 242 works in 27 states, the District of Columbia and the Canal Zone, Panama, in 1917.

Duplex Steel Ingots and Castings.

Included in the 32,476,571 tons of basic open hearth steel ingots and castings produced in 1918 are 3,870,017 tons of duplex steel ingots and castings which were made from metal partly purified in Bessemer converters and finally purified in basic open hearth steel furnaces, against 3,791,830 tons in 1917, an increase of 78,187 tons, or 2.06 per cent. In 1916 the production was 3,436,457 tons and in 1915 it was 1,781,491 tons.

In 1918 duplex steel was produced by 10 works in six states, against 10 works in six states in 1917, nine works in five states in 1916, six works in four states in 1915, and five works in four States in 1914.

Alloy Steel Ingots and Castings.

Production of Alloy Steel Ingots and Castings.

Years	Ingots	Castings	Total	Years	Ingots	Castings	Total
1909	158,978	23,002	181,980	1914	577,107	69,846	646,953
1910	538,462	29,357	567,819	1915	923,251	97,896	1,021,147
1911	425,169	56,290	481,459	1916	1,306,157	56,458	1,362,615
1912	689,392	103,109	792,501	1917	1,576,806	67,529	1,644,335
1913	625,430	88,927	714,357	1918	1,721,367	66,485	1,787,852

Production of Alloy Steel Ingots and Castings, by Processes, Gross Tons, 1918.

Processes	Ingots	Castings	Total
Open hearth steel—basic	1,013,913	10,724	1,024,637
Open hearth steel—acid	323,913	29,191	353,104
Bessemer steel	41,286	23,430	64,716
Crucible steel	54,370	64	54,434
Electric steel	287,885	3,076	290,961
Total	1,721,367	66,485	1,787,852

In 1918 there were 133 works in 22 states and the District of Columbia which made alloy steel ingots or castings.

The total amount of alloy steel ingots and castings produced in 1918 is greater than that produced in 1917. This is entirely due to an increase in alloy steel ingots, the amount of alloy steel castings produced having fallen off slightly.

Rolled Iron and Steel.

In 1918 the production of all kinds of iron and steel rolled into finished forms (including blooms, billets, and axle blanks rolled for forging purposes and semi-finished products which were rolled for export in that year) shows a decrease of 1,911,946 tons, or 5.78 per cent, as compared with the output in 1917.

Total Production of All Kinds of Finished Rolled Iron and Steel, 1914-1918.

Yrs.	Iron and steel rails	Plates and sheets	Nail plate	Wire rods	Structural shapes	All other finished rolled products	Total Gross tons
1914	1,945,095	4,719,246	38,573	2,431,714	2,031,124	7,204,444	18,370,196
1915	2,204,203	6,077,694	31,929	3,095,907	2,437,003	10,546,188	24,392,924
1916	2,854,518	7,453,980	30,088	3,518,746	3,029,964	15,493,093	32,380,389
1917	2,944,161	8,267,616	22,864	3,137,138	3,110,000	15,585,921	33,067,700
1918	2,540,892	8,799,135	18,310	2,562,390	2,849,969	14,385,058	31,155,754

Production of Finished Rolled Iron and Steel by Leading Products, Gross Tons, 1918.

Products	Iron	Steel	Total
Rails		2,540,892	2,540,892
Plates and sheets	14,657	8,784,478	8,799,135
Nail and spike plate	16	18,294	18,310
Wire rods	2,989	2,559,401	2,562,390
Structural shapes	774	2,849,195	2,849,969
Merchant bars	846,898	5,395,851	6,242,749
Bars for reinforced concrete work	468	344,152	344,620
Skelp, flue, and pipe iron or steel	258,500	2,305,511	2,564,011
Long angle splice bars, tie-plate bars, etc.	49,475	367,430	416,905
Hoops		262,281	262,281
Bands and cotton-ties	497	250,270	250,767
Rolled sheet piling, not including fabricated		11,689	11,689
Railroad ties		6,438	6,438
Rolled forging blooms, forging billets, etc.		1,659,118	1,659,118
Exports of blooms, billets, sheet bars, etc.	7,838	824,908	832,746
All other finished rolled products	391,864	1,401,870	1,793,734
Total, gross tons	1,573,976	29,581,778	31,155,754

In addition to the 11,689 tons of rolled sheet piling above reported, there were produced by rolling mills and steel works in 1918 about 1,742 tons of fabricated sheet piling, as compared with 5,294 tons of the same kind of piling in 1917.

Of the total production in 1918, about 94.9 per cent was rolled from steel, as compared with about 94.4 per cent in 1917.

Of the total production in 1918, 44.41 per cent was rolled in Pennsylvania, as compared with 45.42 per cent in 1917; and in 1918, 19.81 per cent was rolled in Ohio, as compared with 18.57 per cent in the previous year.

In 1918 there were 400 plants in 29 states which rolled finished forms of iron or steel, as compared with 387 plants in 29 states in 1917.

NEWS OF THE PLANTS

The Republic Iron & Steel Co., Youngstown, O., has commenced the installation of new machinery at its tube mills for increased capacity in the lap weld department. It is proposed to develop the output to a point to keep this works department up to the production of the lap weld furnaces.

The Black Steel & Wire Company, Kansas City, Mo., has awarded a contract to the W. E. Moore & Co., Pittsburgh, Pa., for engineering and supervision work in connection with its proposed new steel plant. The new plant will be erected and operated as an adjunct to the wire rope mill; it will consist of two furnaces for the production of steel ingots, and be equipped with electric-driven rolls and auxiliary machinery for the manufacture of steel ingots and rolling wire rod bars and shapes. Harry W. Black is president.

The Newton Steel Company, Youngstown, O., recently incorporated with a capital of $3,000,000, is planning for the construction of a new sheet mill works at Newton Falls, Trumbull County. The erection work will be handled by the McClintick-Marshall Company, Pittsburgh, Pa. Edward F. Clark, president of the Liberty Steel Company, heads the new organization.

The Wayne Steel Company, Erie, Pa., is making rapid progress in the erection of its new open-hearth steel plant, and it is proposed to have the works ready for operation some time early in the fall. The plant will comprise two 25-five ton basic open hearth units, with annual capacity aggregating about 30,000 tons. The plant production will be devoted to ingots, blooms, billets, and other specialties. This company also controls the United States Horseshoe Company, and the Canadian Horseshoe Company, Ltd., Hamilton, Ont.

The Youngstown Sheet & Tube Co., Youngstown, O., is now operating all of the six blast furnaces at its works for the production of material for its finishing mills. The company is also operating its two blooming mills, 12 sheet mills nine tube mills, 84 inch plate mill, and 9 and 12 inch mills. It is understood that capacity operations will be maintained for some time to come.

The Blaw-Knox Company, Farmers Bank Building, Pittsburgh, Pa., manufacturer of iron and steel specialties, electric transmission towers, etc., has acquired property, about 100x 100 feet, in the vicinity of its works at Hoboken, Pa., for the erection of an addition. The company is concentrating operations at this works, having disposed of its plant at Wheatland, Pa., to the Sharon Steel Manufacturing Company. It is planned to increase the capacity of the Hoboken works for the manufacture of products heretofore produced at the Wheatland plant.

To provide for the proposed expansion in connection with the recent merger of interests, the Clinton-Wright Wire Company, Worcester, Mass., has perfected plans for a bond issue for $3,500,000. The company has six plants at Worcester, Palmer and Clinton, Mass., with an aggregate manufacturing space of about 36 acres, and giving employment to 2,500 persons. It is one of the largest manufacturers of wire and wire products. George M. Wright is chairman of the board of directors.

Follansbee Brothers Company, Pittsburgh, Pa., is considering plans for the construction of a new tin manufacturing works near Steubenville, O. The company proposed to duplicate its present mills at Follansbee, Va., at the new location, with initial operating and manufacturing facilities to provide for the employment of about 1,000 men.

The Eastern Rolling Mill Company, Lexington Building, Baltimore, Md., recently organized, has perfected arrangements for a stock issue aggregating $3,000,000, for the erection of its proposed new plant in the eastern part of the city. Initial construction has been inaugurated on the 15-acre tract in this section, recently secured, to include three main buildings and a number of smaller structures. The new plant is estimated to cost about $1,000,000, and will be equipped for the manufacture of steel sheets for use in the production of automobile hoods, bodies, fenders, etc. The Belmont Iron Works, Philadelphia, Pa., has secured a contract for the building.

The Western Rolling Mill Corporation, Hoquiam, Wash., recently incorporated with a capital of $2,000,000, has commenced the construction of its proposed new local plant on a tract of about six and one-half acres of property. The works will be erected on the unit plan, the first unit to have a daily capacity of about 100 tons of material, and estimated to cost $250,000, including machinery and equipment installation. This latter will embrace open hearth furnaces, mill machinery, electric traveling cranes, hoisting apparatus, and about 1,200 horsepower in electric motors. An open hearth furnace and one continuous furnace will be constructed in connection with this unit, and at a later date an electric furnace will be added. The new works will specialize in the production of steel bars and kindred specialties. It is planned to have this unit complete and in actual operation early in the coming year, with employment given to about 100 men.

The Steel & Tube Co. of America, Chicago, Ill., is considering the construction of a new blast furnace at the South Chicago plant of the Iroquois Iron Company. Blast furnace No. 3 at this plant is now being rebuilt.

The Wickwire Steel Company, Buffalo, N. Y., is making extensions and improvements in two of its blast furnaces. It is expected to complete the work at an early date.

The Rogers-Brown Iron Company, Erie County Bank Building, Buffalo, N. Y., is planning for the construction of a one and two-story addition to its plant, about 66x260 feet, to cost about $75,000, including machinery and equipment.

The Standard Steel Car Company, Pittsburgh, Pa., is said to be planning for extensions and improvements at its plant at Middleton, Pa., to increase the present capacity, which averages about 35 steel cars per day.

After being shut down since the latter part of April, the Bethlehem Steel Company has resumed operations at its Bessemer mill at the Steelton, Pa., plant. With this mill in operation, open hearth furnaces Nos. 14 and 15 have been placed on the duplex system, increasing the capacity of the plant by about 300 tons of steel per day.

The Inland Steel Company, Chicago, Ill., is considering plans for the construction of about 24 additional sheet mills at its works at Indiana Harbor, Ind. It is proposed to build about 16 of these units in the near future, with the balance at a later date. In connection with this proposed expansion, facilities will be provided for the production of steel sheets for automobile and kindred use.

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INDUSTRIAL RELATIONS

RELATIONS BETWEEN EMPLOYER AND EMPLOYE

(Continued from Page 396.)

the qualities and characteristics of the worker needed to fill the job, and to indicate additional help required, whether it is to replace a person who has left or whether it is to increase the size of the force. To facilitate the requisitioning of labor, a good many plants have carefully analyzed each job and made standard descriptions of them so they could be referred to by a number or a sign.

From the requisition the person in the employment department who is to select the labor should get his exact knowledge of the requirements, physical, mental, moral, and the degree of trade knowledge and skill needed for the place, and the age, sex, and nationality that experience has proved to be the most fitted for the work. But more important even than knowing the exact nature of the job is a knowledge by the employment man of the nature of human beings, and the kind of work that they can do and have done. Each applicant must be given a private interview, for in no other way is it possible to find out exactly the kind of work that he is fitted for and to prevent him from being assigned to duties which are beyond his abilities or his strength. in the selection interview, care must be taken not to make any promises to the applicant which the company is not in a position to fulfill. Any unwarranted promises will develop ill feeling among the employes against the company.

No matter how unskilled a job is, there are wrong nad right ways to do the job. New employes must be taught the right way. Mere delivery of the man to his foreman is not enough. First the new employe must be introduced to his fellow workers, and the shop rules, practices and conveniences must be carefully pointed out and explained to him. Someone must see to it that he is properly broken in and trained for his work. The foreman may be a good production man but a very poor teacher. Most of the labor turnover in a plant is caused by employes leaving who have been employed less than a month. This shows that once they get over the strangeness of the new surroundings and the new work they become steady employes. Only careful induction and training of new employes will serve to overcome labor turnover loss from this cause.

No desirable employe is willing to work at an employment that offers no opportunity for advancement or promotion. Advancement may sometimes take the form of increase in wages, but more often it means promotion to a better job. Organized machinery for seeing that employes are promoted when they deserve it is a prime essential in any industrial relations organization. This cannot be provided by leaving the matter entirely in the hands of the foreman, because foremen do not want to lose good men from their departments, and they are not informed as to the best opportunities in other departments. An overhead organization like the employment department must be vested with the responsibility for following the careers of the individual workers and searching out the opportunities in the various departments of the plant for promoting the best employes. Besides promotion, transfers from one department to another are often necessary to readjust misplacement of employes and to take care of fluctuations in the amount of work in the various departments. This, too, must be handled by an overhead organization like the employment department, otherwise one foreman will be discharging employes while other foremen will be hiring new help. Both in the matters of promotion and transfers the foreman's responsibility must be limited to recommendations as to the character of the man's work and to seeing that his employment in the particular department is properly begun and terminated. The responsibility for initiating and arranging promotions and transfers must rest on the employment department, which deals with all the departments in the plant.

The employer may consider the mistakes in a worker's pay, slighting remarks by foremen, complaints of favoritism or unjust treatment as mere incidents and not very important. He lets it go with "Take it up with your foreman,' who may be the very cause of the difficulty. In the minds of the employes, however, these little troubles look very large, and unless means are provided for making complaints and hearing grievances, a feeling of resentment grows up among the workers in the plant that the management cannot understand. To prevent any employe from suffering from a sense of injustice the general manager either must set aside regular hours when he will be ready to talk over with his employes any of their problems, or else he must put this duty on to the employment or labor manager. Someone in the organization above the foreman must be made responsible for seeing that a square deal is assured to every employe; and not only that, but also to see that the employe really feels that he is getting a square deal.

Whether an employe is dismissed or quits of his own accord, he should be interviewed by the labor manager before he is finally paid off, to get at the real reason for leaving or discharge. Only by such a system of separation interviews can the employer be sure that the employes are wisely or justly discharged, and there is no better way to find out causes of dissatisfaction among employes and to get suggestions for making improvements. It is just as good business policy to have employes who leave the firm go away thinking well of the company as it is to see that customers remain kindly disposed toward the company.

In proportion as the employment organization is efficiently operated and the hiring, training, promotion and management of employes are properly handled, there will be less need for so-called "welfare" work to keep employes contented. Personal service work will, however, always be needed. The safety and accident prevention movement is sufficiently developed to require little more than mention here. Sanitary conditions in the factory and protection of the health of employes by industrial physicians and nurses are also plain business measures for decreasing sickness, absences, spoiled work and for increasing production. Of the other welfare activities, such as entertainments, athletics, schools, vacation camps, insurance and pensions, profit sharing, etc., those only will be needed which actually aid in building up spirit and morale that result in increased production.

Employers who deal with trade unions or who wish voluntarily to give their employes a voice in determining wages, hours, working conditions and shop government, have, in addition to the above, to operate the machinery for handling the economic or collective labor relations. Where an agreement is made with a union the methods of collective bargaining will be contained in the agreement. Where the employer wishes to inaugurate collective bargaining he will begin this by creating shop committees or an employe representation plan of some kind. Experience has shown that the best method of handling this is for the management not to devise some plan of its own to be submitted to the employes, but rather to ask the employes to elect representatives who together with the management will work out a plan approved by both. In this way the employes will not be as likely to criticise minor defects in the plan, for they will feel it is of their own making.

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Some Pointers on By-Product Coke Oven Operations

NORTHWESTERN PRESSURE REGULATOR.

The following gives a brief description of the Northwestern Regulator for by-product coke plant regulation:

The Northwestern pressure regulator is a gasometer controlled motor for operating a damping valve, engine throttle, or whatever element governs the gas flow. The gas pressure to be regulated is piped into the gasometer, within which is a light, rugged, balanced float, immersed in oil, and mounted on knife edges. The gasometer switch operates the control switches which in turn operate the motor. The motor drives, through reduction gearing, a shaft extended to the outside of the regulator housing and connected to the valve under control.

All parts are extremely rugged and positive in operation; a quarter millimeter of pressure moves the float switch from one contact to the other.

The gasometer casing is provided with a rubber gasket which, on excessive pressure, seals off the float and prevents gas from blowing through. A movable weight on the gasometer switch arm allows the pressure to be adjusted from 2 mm of suction to 6 mm of pressure, a range of 8 mm.

The magnetic switches, operated from the gasometer switch contacts, control the direction of rotation of the motor and are arranged with dynamic braking contacts for stopping the motor instantly when the switch opens. The switch solenoids are also provided with condensers to make the switch open at once when the gasometer contacts open. These condensers also greatly reduce the arcing and wear on the gasometer contacts.

The motor is direct current, compound wound, reversible, and fully enclosed to prevent corrosion from the gas, the enclosure over the commutator being of heavy glass makes inspection possible without opening the enclosure. In certain installations the motor is wound for two speeds, the gasometer switch first produces normal speed on the motor, then if the gasometer moves still further from the neutral position, secondary contacts close, which produce very much higher speed on the motor.

The motor drives the crank shaft through cut spur gears, steel worm and cut bronze segment. The crank shaft extends through the housing and carries a 10 inch adjustable crank arm, which is connected to the arm of the butterfly valve. If the valve is a gate instead of a butterfly, the regulator motor is direct connected through gears.

The total gear reduction is very great, so that a load on the crank arm, sufficient to stall the motor, will twist off a 2¼ steel shaft. The motion of the butterfly valve is very positive; dirt and clogging have no effect on it.

Limit switches are provided at each end of the crank's arm's travel. These switches, as well as the gasometer switch and the magnetic switches, all have readily renewable graphite arcing contacts.

The regulator parts are mounted on a heavy cast iron base with a 3/16 inch boiler iron house over them. Heavy cast iron doors with leaded joints, are hung on the front, locked shut with swing bolts.

They are held in the full open position by gravity. The middle door has a wire glass panel for inspection of the interior.

Plant Installation.

In compact one block plants it is usually necessary to install a gasometer only on the oven end of the suction main and arrange the exhauster engine to be speed controlled from this gasometer. Several plants are now in operation on this system, with which they get good regulation. This is known as system No. 1.

If, however, the gas main is long, the exhauster or its engine have heavy fly wheel parts, or there are other conditions which bring time lags into the gas pumping plant, it is necessary to go to system No. 2. In this system a gasometer operating a butterfly valve is placed at the oven end of the gas main, and there is also a speed controller on the exhauster engine. The regulator at the ovens operates its butterfly in the usual way, to hold the pressure on the ovens. The speed controller on the exhauster engine varies the engine speed only when the butterfly valve on the ovens becomes too nearly closed or too wide open. Instead of holding a fixed suction in front of the exhauster, it continuously operates the engine at that speed which will keep the oven butterfly near its middle or most efficient position. The engine controller and the gasometer regulator are so interconnected that there is no possibility of hunting or see-sawing.

Since the foretelling of the regulating characteristics of a new plant is extremely difficult, it has become the practice, in planning the regulators for a new one block plant to install system No. 1. If then, after the plant is put into operation, the regulation is unsatisfactory it is merely necessary to add a motor driven butterfly valve at the ovens, and the system is converted into No. 2. There is practically no difference in the amount of material used, whether a system No. 2 is built up in this way from a No. 1, or whether a No. 2 is installed in the first place.

System No. 3 consists of system No. 2 expanded, to fit as many blocks as there are in the plant. The standard butterfly regulators on each block are interconnected with each other and with the exhauster engine speed controller in such a way that whenever any one butterfly gets too far away from its best operating position, the exhauster speed is changed slightly so that the change in suction will bring the butterfly back to its working position.

Instead of attempting to govern the gas pumping system by several independent regulators in various parts of the system, it is governed by one regulator, this regulator consisting of several dependent and interconnected parts, all centrally controlled.

The advantages of this system can be summarized as follows:

1. The suction maintained by the exhausters is not an arbitrarily fixed one, but is that suction which produces the best operation on the oven butterflies.

2. This "best operation" suction is automatically varied from time to time as the gas conditions vary.

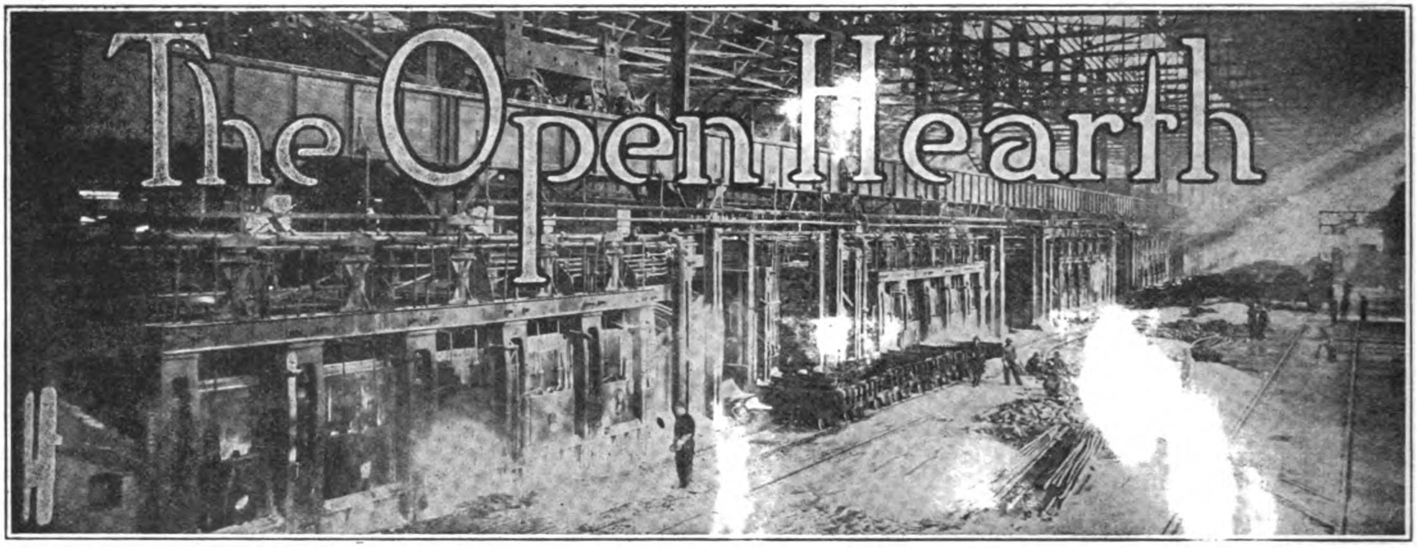
3. There is no possibility of hunting or see-sawing in any part of the system.

4. The speed of the exhauster engine is changed gradually and infrequently—never suddenly nor in rapid succession.

5. The small sudden variations in oven pressure are corrected by the extremely sensitive oven butterflies, while the slower and larger changes in the gas system are corrected by the slower acting exhauster controllers.

6. If gas conditions become so abnormal that the regulating system cannot correct them, the regulator is arranged so that it ceases all operation. Considerably before it ceases functioning it operates signals warning the operator of the approaching gas danger.

7. Signals and indicators, located at central points, show at all times the complete condition of the gas and regulator system.



The Open Hearth

J. H. Van Campen is now connected with the Midvale Steel & Ordnance Co., Coatesville, Pa. He was formerly steel plant engineer for the Timken Roller Bearing Company, Canton, O.

V V

Frank R. Coleville has resigned as sales manager of the Reno-Kaetker Electric Company, Cincinnati, and has joined the sales force of Eaton, Rhodes & Co., pig iron and coke dealers.

V V

William Lewis has been appointed to take charge of the Falcon Steel Company plant, being built at Niles, O. Mr. Lewis was formerly superintendent of the sheet mill plant of the Western Reserve Steel Company, later acquired by the Brier Hill Steel Company.

V V

H. M. Steele will take the position of operating manager of the Newton Steel Company, which company will erect a sheet plant at Newton Falls, O. Mr. Steele was formerly vice president and general manager of the Liberty Steel Company.

V V

Capt. Henry A. Butler sailed July 10 from France, where he has been in the service of the American Red Cross. Mr. Butler will later resume his duties as head of the cost department of the Youngstown Sheet & Tube Co., which position he held before going to war.

V V

George W. Way, formerly connected with the Carnegie Steel Company, at Detroit, has been appointed Michigan representative for the Erie Crucible Steel Company, Erie, Pa.

V V

Thomas P. Davis succeeds William Ahlen as chief engineer of the Duquesne Steel Works of the Carnegie Steel Company the latter having returned to his home in Sweden.

V V

Albert Cummins is now electrical engineer of the Duquesne Steel Works of the Carnegie Steel Company, succeeding Carl Cedarlund, who has resigned to become electrical engineer for the General Electric Company, of Sweden.

V V

John W. Watson, Jr., is now assistant manager of the Canonsburg Steel & Iron Works, Canonsburg, Pa.

V V

M. L. Fellmer has been appointed secretary of the Central Mississippi Valley division of the National Safety Council, St. Louis, succeeding Carl L. Smith, who will be public safety field secretary.

V V

F. V. Larkin, formerly connected with the Harrisburg Pipe & Bending Co., Harrisburg, Pa., will be professor and head of the department of mechanical engineering, Lehigh University, Bethlehem, Pa.

Wil[illegible] [illegible]n, formerly assistant superi[illegible]ent of No. 3 op[illegible]ead works, Carnegie Steel [illegible]pany, is now s[illegible] the Franklin open hearth depa[illegible]nt Cambria [illegible]nstown, Pa.

V V

[illegible] r. [illegible]erly captain in the ordnance department and w[illegible]ward Iron Company, Woodward, Ala., is now assistant foundry superintendent of the Kanawha Manufacturing Company, Charleston, W. Va.

V V

William E. Corey, chairman of the Midvale Steel & Ordnance Co., Philadelphia, has been elected a director of the Sinclair Consolidated Oil Corporation.

V V

Edward N. Hurley's resignation as chairman of the United States Shipping Board has been accepted by President Wilson, effective August 1.

V V

T. L. Lewis has withdrawn his resignation as sales manager of the A. M. Byers Company, Pittsburgh, and will therefore continue in that position.

V V

D. C. Schulte, Sr., has again taken up his position as sales manager of the Pittsburgh Crane & Equipment Co., Sharpsburg, Pa.

V V

E. J. Good, who is assistant purchasing agent of the American Steel Export Company, has sailed for China.

V V

H. B. May, formerly connected with the Youngstown Sheet & Tube Co., as efficiency engineer, is now connected with C. E. Knoeppel & Co., Inc., New York.

V V

T. S. Disler, traffic manager of the Fort Pitt Steel Castings Company, McKeesport, Pa., has also been appointed purchasing agent of that company.

V V

Lieut-Col. Elmer K. Hiles, formerly secretary of the Engineers' Society of Western Pennsylvania, and later of the engineering department of the American expeditionary forces, is now connected with the Pittsburgh Testing Laboratory as manager of laboratories, with headquarters in Pittsburgh.

V V

L. G. Knight, for some time manager of sales for the Pacific Coast Steel Company, San Francisco, with headquarters at New York, will be transferred to the Seattle works of that company. W. Truesdale, who recently returned from France will succeed Mr. Knight at New York.

V V

George F. Hamfeldt, who was at one [illegible] superintendent of the Carrie furnaces of the Carnegie St[illegible]any, and was actively engaged in the steel industry, was [illegible]burgh recently

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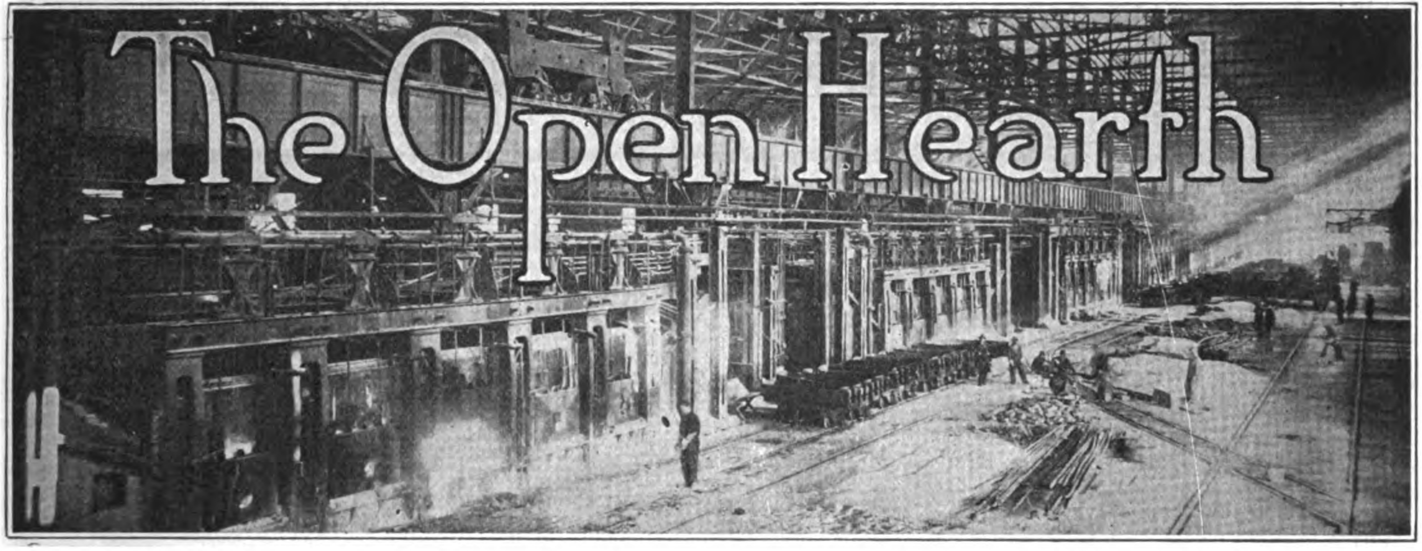


after having been out of the country for over 10 years. Mr. Hamfeldt was for some time connected with a large German steel company in Lorraine, and later went to Sweden to form the Oxelosunds Iron Works at Oxelosund, of which company he is now president.

V V

Francis S. Carr, vice president of the Pennsylvania Steel Export Company, Philadelphia, arrived recently from a business trip in Europe. Mr. Carr secured some business in England, about 8,000 tons of steel, but found difficulty in closing orders in France.

V V

Thomas E. Farrell, formerly with the Ohio Corrugating Company, Warren, O., has resigned and is now president and treasurer of the Sheet Metal Manufacturing Company, Youngstown, O. This is a recently organized corporation which will manufacture and wholesale sheet metals.

V V

H. A. Brassert was elected chairman of the board of directors at a recent meeting of the directors of Freyn, Brassert & Co., Chicago.

V V

D. B. Coey is now Chicago representative at the Mansfield Sheet & Tin Plate Co., Mansfield, O., with offices at 1134 National Life Building, 29 South La Salle street, Chicago.

V V

J. H. Schoenley is now connected with the Bethlehem Construction Company, Bethlehem Trust Building, Bethlehem, Pa. Mr. Schoenley was formerly manager of sales of Josef F. A. Comstedt, steel, iron and metals, New York.

V V

Robert S. Maddocks is now connected with the sales force of the Cambria Steel Company. He was formerly assistant secretary of the Smiley Steel Company, New York.

V V

Warren F. Perry, for many years secretary to the general superintendent of the Carnegie Steel Company, Youngstown district, has been appointed assistant to the president of the Brier Hill Steel Company, Youngstown, O., in charge of industrial relations. Mr. Perry was also superintendent of transportation for the Carnegie Steel Company, in the Youngstown district.

V V

Thomas O. Morgan, until recently head of the service department of the New York office of the American Steam Conveyor Corporation, has been promoted to the position of sales engineer. He will handle Long Island and Connecticut territory. Mr. Morgan's sound experience in service work has been a splendid training for his new responsibilities and his customers are assured of receiving authoritative advice on correct ash disposal engineering.

The American Steam Conveyor Corporation has just announced the appointment of H. S. Valentine as sales engineer, in charge of Philadelphia territory. An office has been established in the North American Building, Philadelphia. Mr. Valentine is an experienced mechanical engineer and was connected with the Link-Belt Company, of Philadelphia, for 5½ years, with the Brown Hoisting Machine Company and Yale & Towne Manufacturing Company, for six years, and with the Badenhausen Company for one year.

V V

W. Woodward Williams, formerly general manager of the A. M. Byers Company, Inc., Pittsburgh, is now general manager of the Reading Iron Company, Reading, Pa. Mr. Williams has held numerous positions as operating official. He was for some time connected with the Carnegie Steel Company, and later he was in the sales department of Bourne-Fuller Company.

V V

B. L. Cogshall, formerly connected with the United Alloy Steel Corporation, Canton, O., is now assistant to President John Bindley, of the Pittsburgh Steel Company.

V V

George E. Jurey has been appointed auditor of works of the Jones & Laughlin Steel Company, Pittsburgh, Pa. He was formerly chief clerk in the open hearth department of the Republic Iron & Steel Co., Youngstown, O.

V V

Malcolm E. Gregg is now connected with the general sales office of the Lackawanna Steel Company, Buffalo. He was formerly with the district sales office of the Republic Iron & Steel Co., Chicago.

V V

Randolph Owens, who has been connected with the St. Louis office of the American Sheet & Tin Plate Co. for many years, has been transferred to the Philadelphia office.

V V

John W. Barrett has been appointed fuel inspector for the Youngstown Sheet & Tube Co., Youngstown, O. His headquarters will be in the Oliver Building, Pittsburgh.

V V

Walter Schultz has been appointed chief engineer of the Slick-Knox Steel Company, Wheatland, Pa.

V V

H. B. Folsom has been elected treasurer of the Brier Hill Steel Company, succeeding John Stambaugh, resigned. Mr. Stambaugh will continue as a director.

V V

C. A. Ducharme has been transferred from the Philadelphia sales office of the Republic Iron & Steel Co., to the Boston office.

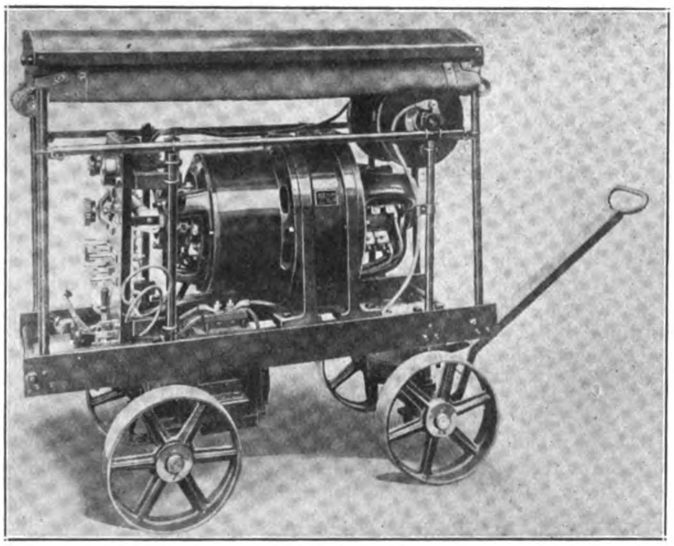
WITH THE EQUIPMENT MANUFACTURERS

ELECTRIC ARC WELDER FOR PORTABLE AND STATIONARY USE.

After an exhaustive investigation into the requirements of machine shops, railroads and shipyards, the United States Light & Heat Corporation of Niagara Falls, N. Y., has developed a line of electric arc welding machinery that meets the requirements for every character of work.

For shops where it is practicable to bring the parts to be welded to within 50 or 75 feet of the welding apparatus, a stationary type is provided; also a light weight portable machine is made which may be taken direct to the work whether it be in the shop or yard.

With a rated capacity of 4 kw USL arc welder gives 200 amperes direct current, or less, with an arc voltage of 17 to 22 volts and open circuit voltage of 35 to 65 volts. It is made in the form of converter for use on 100 to 125 volts dc circuits only, and in the form of a motor-generator for all other ac and dc circuits. Weighing only 665 pounds, the converter delivers current at the arc through the arc stabilizing reactor with the remarkably high efficiency of 65 to 70 per cent.



View of portable electric arc welder.

The motor-generator type consists of a 7½ hp ac or dc motor on the same shaft with a 4 kw USL welding generator. Inherently regulated, compound wound, self excited, and with drooping voltage characteristic, it is claimed that the generator, as well as the converter, produces an arc peculiarly suited to arc welding.

Producing practically constant energy in the arc and responding instantly when the electrode touches the work, the USL machines assure a strong steady arc with a constant flow of metal into the weld.

For portable use a truck equipped with motor-generator, or converter, panel, reactor, cover and cable reel is supplied. The truck which is 28 inches wide, 55 inches high over cover, and 54 inches long, weighs with complete equipment about 1,500 pounds.

A catalog describing the USL electric arc welding machinery, and giving the advantages of this type of machine over other welding methods, has been prepared and is now ready for distribution.

EFFICIENCY OF MOTOR-DRIVEN CENTRIFUGAL PUMP.

That the efficiency of centrifugal pumps is still climbing and that under certain circumstances water works pumps can profitably be operated with central station power is shown by the report of an acceptance test made upon a motor-driven pump at the Minneapolis water works.

In a paper read before the Minnesota Section of the American Water Works Association, F. W. Cappellen, city engineer of Minneapolis, stated that in May, 1911, the city entered into a 10-year contract with the Minneapolis General Electric Company, now the Northern States Power Company, by which that company agreed to furnish current at 2,200 volts to operate two or more 20,000,000 gallon pumps against a dynamic head of 240 ft., based upon a pumping set of 72 per cent overall efficiency, at a price of $4 per 1,000,000 gallons pumped, the understanding being that no current would be used between 4:15 p. m. and 6:30 p. m. on week days during the months of November, December, January and February. In November, 1916, a similar 10-year contract was made with the same company for the operation of a 30,000,000 gallon pump against the same head, and with the same pump efficiency, to be charged for at the same rate, with the provision that at a different dynamic head or efficiency, the price per 1,000,000 gallons should be adjusted accordingly. It was also specified that the motor to be used by the city should be capable of starting the pump when primed and with the check or gate valve in the discharge closed, and of bringing the pump to full speed without drawing more than 150 per cent of full load current from the source of supply. In 1911, two 20,000,000 gallon Worthington pumps were installed, and in 1918, a De Laval pump.

The latter unit consists of a General Electric 1,800 hp three-phase, slip-ring induction motor directly connected to two De Laval 24-inch single-stage pumps mounted upon the same base plate and connected in series. The unit was specified to deliver 30,000,000 gallons per 24 hours against a total dynamic head of 250 feet. It was supplied by the Minneapolis Electric Equipment Company, and is installed at Pumping Station No. 4 in Northeast Minneapolis.

The official acceptance test was made on May 28 and 29, 1918. The discharge was measured by means of a Venturi meter, the capacity being calculated from manometer readings, while the discharge head was measured by two sets of calibrated gauges and the suction lift by means of a mercury column. The power supplied was measured by three sets of watt-hour meters, calibrated by means of a portable set of standard instruments read during the official test under the conditions of current, voltage and power factor obtaining. The portable set included two single-phase watt meters, one polyphase watt-meter, one volt meter, four ammeters, and portable current and potential transformers. All instruments were checked and calibrated in the presence of witnesses. The test lasted 28 hours.

The results were as follows:

Total pumpage in 28 hours, 37,719,500 gallons.
Rate per 24 hours, 32,331,000 gallons.
Discharge head, average, 235.13 feet.
Suction lift, average, 16.43 feet.
Total dynamic head, average, 251.56 feet.
Kilowatt hours used, 36,307.2.
Combined efficiency of motor and pump, 82.1 per cent.
Average line voltage, 2,406.
Power factor, 90 per cent.
Motor efficiency under test conditions, 95.5 per cent.
Slip of induction motor, 1.1 per cent.
Temperature rise, 33.5 degrees C.
Starting current, percentage of full load current, 113 per cent.

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WITH THE EQUIPMENT MANUFACTURERS

The contract of the city with the Minneapolis Electric Equipment Company, provided a bonus of $500 for each 1 per cent of efficiency exceeding 76 per cent when pumping 30,000,000 gallons per day against a total dynamic head of 250 feet. The maximum bonus was limited to $2,400. A penalty of $500 was provided for each 1 per cent by which the efficiency might fall below 76 per cent and the pump was not to be accepted if the overall efficiency fell below 72 per cent. As the accompanying chart shows, 76 per cent efficiency was exceeded at all loads tested, and the average combined efficiency, including the regular starting and other conditions incidental to a varying load in regular service should not be less than 82.1 per cent by more than 1 per cent. The overall efficiency of 82.1 per cent divided by the motor efficiency of 95.5 per cent gives a pump efficiency of 85.97 per cent. This is believed to establish a new record and is 6 per cent higher than the results obtained in the tests on the pumps of another make installed by the City of Minneapolis under similar conditions. Service runs extending over a period of three months show an excess of 5 per cent over the efficiencies stipulated in the contract for various heads.

The test was accepted as correct by J. D. Marshall, of the Minneapolis Electric Equipment Company, William Salt of the De Laval Steam Turbine Company, J. E. Jensen, supervisor of the water works department, and E. C. York, engineer of pumping stations. The foregoing information is taken from the official test of the report by Prof. F. W. Springer, of the University of Minnesota, who was in full charge of the test, so far as the city was concerned.

The following comparative operating data was obtained during the first three months after the test:

De Laval 30,000,000 Gallon Pump—Gallons pumped, 2,797,490,000; power cost per 1,000,000 gallons, $3.63; labor and supplies per 1,000,000 gallons, $2.27; total cost per 1,000,000 gallons, $5.95; head, ft., 253.06; overall efficiency, per cent, 81.4.

Worthington 20,000,000 Gallon Pump—Gallons pumped, 421,340,000; power cost per 1,000,000 gallons pumped, $4.15; labor and supplies per 1,000,000 gallons pumped, $2.27; total cost per 1,000,000 gallons, $6.42; head, ft., 250.57; overall efficiency, per cent, 72.3.

Similar records for the first nine months subsequent to the test are as follows:

De Laval 30,000,000 Gallon Pump—Gallons pumped, 6,526,350,000; power cost per 1,000,000 gallons, $3.72; labor and supplies per 1,000,000 gallons, $1.77; total cost per 1,000,000 gallons, $5.49; head, ft., 255.80; efficiency, per cent, 82.48.

Worthington 20,000,000 Gallon Pump—Gallons pumped, 1,771,930,000; power cost per 1,000,000 gallons, $4.33; labor and supplies per 1,000,000 gallons, $1.77; total cost per 1,000,0000 gallons, $6.10; head, ft., 257.80; efficiency, per cent, 71.4.

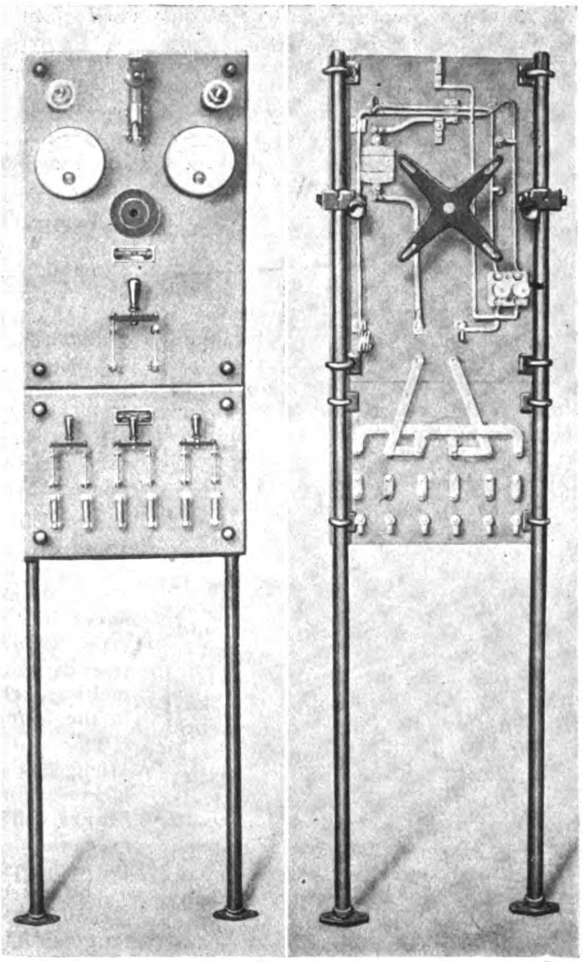
Figures are also available from two triple-expansion Holly-A frame pumps installed in the same plant in 1903 and 1904, and tested in September, 1904. These pumps have a capacity of 15,000,000 gallons per day each, and on test developed a duty of 162,000,000 ft. lb. per 1,000 pounds of steam, reduction being made for slip. During 1908 the two steam pumps raised practically all of the water for the city, namely 6,518,000,000 gallons against 250 ft. head. The cost of fuel, using Illinois screenings at $2.07 per ton, was $3.01 per 1,000,000 gallons, the cost of labor $3.33, and other pumping costs 35 cents per 1,000,000 gallons, making a total of $6.75. The cost today, with coal at $4.93 per ton, would be approximately $12.74 per 1,000,000 gallons. The low prices which the city realizes on its power contracts with the electric company are of course explainable in that the contracts were made some time ago and for a long term.

READY TO WEAR SWITCHBOARDS.

Switchboards which are particularly adapted for smaller installations, are the Westinghouse ready to wear kind. This switchboard is suitable for the control of a direct-current generator and three lighting circuits.

One feature of this type of switchboard that is particularly in its favor, is that it can be placed in operation by simply connecting the leads from the generator and feeder circuits to the terminals provided for that purpose.

The installation of the old types of switchboard involved a great deal of detail work. First of all each piece of detail apparatus must be ordered with careful consideration given to the type and capacity. Drilling templates of each must be secured and considerable sum must be allowed to cover investment in machines and tools for drilling the slate and bending the copper strap connections. Finally, when the panel is built up and installed, it may operate and it may look pretty good, but one cannot be absolutely certain.



Front view of K. D. panels. Back view of K. D. panels.

The accompanying illustration is typical of the types K. D. and J. D. panels, both of which are suitable for 125 and 250 volts installations up to 600 amperes capacity, which are manufactured by the Westinghouse Electric & Manufacturing Co. at East Pittsburgh, Pa. Both the K. D. and J. D. type of panels permit a choice in number and capacity of feeder circuits.

Trade Notes

Frank O. Leitzell has been appointed to the corps of engineer salesmen, in the sheet and tin mill specialties department of the Blaw-Knox Company. Mr. Leitzell is a graduate of Pennsylvania State College, '07, and was formerly with the H. K. Porter Company, Pittsburgh, Pa., where he held the position of assistant to general manager.

The Mesta Machine Company has received an order from the Cambria Steel Company at Johnstown, Pa., for two 48" and 84" and 84" and 84x60" steam blowing engines. These engines are similar to four other Mesta steam blowing engines installed at this plant some time ago.

They are also building two 24" and 52x36" unaflow type blowing engines for the Tata Iron & Steel Co., as well as one 42" and 84" and 84" and 84x60" steam blowing engine for the Pittsburgh Crucible Steel Company.

They have completed shipment of two 34" and 72" and 84" and 84x48" steam blowing engines for the Phillips Sheet & Tin Plate Co. The Mesta Machine Company also secured the order for a 40" blooming mill for the Wheirton Steel Company.

That the foundry industry in the Middle West is suffering no depression is clearly evidenced by the extensive building operations throughout that section. A large percentage of the demand for castings finds its source in the automobile business, but other lines also show great activity. Holcroft & Co., contracting engineers, Detroit, say that a close survey by their Philadelphia office show considerable improvement in foundry conditions through the Eastern section, that many concerns are getting out plans for extensions and are replacing considerable old equipment. In addition to a large volume of work not given general publication and many large contracts pending, Holcroft & Co. have the following jobs under construction. Two batteries of core ovens for the D. J. Ryan Foundry Company, two batteries of core ovens for Whitehead & Kales Iron Works, and a battery of core ovens at the Kelsey Wheel Company, and batteries at the Monarch Foundry Company and Charles B. Bohn Foundry Company, all of Detroit. A battery of five ovens for Novo Engine Company, Lansing, Mich., a battery of six core ovens for the Hamilton Foundry & Machine Company, Hamilton, O., two batteries of four core ovens for the Saginaw Malleable Iron Company, Division of General Motors Corp., Saginaw, Mich., 32 core ovens for Central Foundry Company, Saginaw, Mich., 30 ovens at the Wilson Foundry & Machine Company, Pontiac, Mich., another battery of four core ovens for the Nash Motors Company, Kenosha, Wis., and two more batteries of four ovens each for the Maxwell Motor Company, Dayton, O. The construction of a 20-ton open hearth furnace was completed for the Monarch Steel Castings Company, Detroit, last week and other open hearths will be started at other locations within the next few weeks. Holcroft & Co. say there is a scarcity of firebrick masons and skilled workmen in building trades and the situation is becoming acute despite the high wages paid.

The Corrugated Bar Company, Inc., of New York, announces that it has taken over the entire assets and liabilities of the Corrugated Bar Company, a Missouri corporation, and is continuing the business of the latter company, which is in process of dissolution. This means the retirement by purchase of the Garrison interests, which held the majority of the stock of the Missouri corporation from its inception in 1891, until the recent reorganization. The control now passes to A. L. Johnson, who has been connected with the company since July, 1895. The officers and board of directors of the new corporation are: A. L. Johnson, president; W. H. Kennedy, vice president and treasurer; Ralph McCarty, secretary; A. E. Lindau, general manager of sales; Lyman Bass, of the firm of Kenefick, Cooke, Mitchell & Bass, counsel.

A meeting of the board of directors of the Aetna Foundry & Machine Co., Warren, O., was held at the office of the company. Those present were M. W. McClane, W. M. McKee and G. P. Gillmer. The resignation of W. W. Ludt of Youngstown, as director, was accepted and Victor E. Rehr, general manager of the company was elected to fill the vacancy. Considerable satisfaction was expressed at the very encouraging outlook for increased business.

The Electric Furnace Company, Alliance, O., has just installed a battery of two Baily electric furnaces at the Capital Brass Works, Detroit, Mich. These furnaces are the standard 105 kw tilting type with hearth capacities of 1,500 pounds each. They will be used for melting yellow brass scrap and borings in the foundry.

The Buick Motor Company, Flint, Mich., has just purchased a second Baily electric furnace for melting phosphor bronze. The furnace is of the tilting type, rated at 1,500 pounds hearth capacity, and an electrical capacity of 105 kw.

The Akron Bronze & Aluminum Co., Akron, O., has installed a 50 kw rectangular tilting type, Baily electric furnace in its jobbing foundry. This furnace has a hearth capacity of 300 to 500 pounds and will be used for a wide variety of compositions. Heats will range from 100 to 500 pounds and will include gun metal, phosphor bronze, red and yellow brass.

The Treadwell Engineering Company, Easton, Pa., has recently purchased additional frontage along the Lehigh & New England Railroad, to make room for additions to their plant. Ground has already been broken for a 220x90 ft. extension to the main erection shop which is designed for the heaviest class of work and will include a full equipment of cranes, tools, etc., also a new central heating system is under construction for the shops and office building. These plans also include the erection of a second steel foundry for heavy steel castings and additions to the iron foundry. These additions are necessary to handle the product of the plant as this company has lately developed a large export trade in addition to their regular line of steel works equipment.

The Cambria Steel Company are installing a new gas house to contain 51 producer-gas machines for service at their Franklin furnaces, and the Weirton Steel Company, Weirton, W. Va., are building an entirely new open hearth and blooming mill plant containing 27 producers. Both of these buyers selected the Morgan producer-gas machines which have been growing steadily in favor for the past three or four years. In addition to this new business the same selection has been made by four leading British steel plants this year. The Morgan Construction Company of Worcester, Mass., feel that the long contest between the old method of stirring gas fires with mechanical pokers and the newer method of continuous leveling is now practically over and that a valuable advance in the art of gas making has been established. About 500 of these splendid machines are in operation or contracted for.

The Blaw-Knox Company announces the appointment of L. C. Murray to their corps of engineering-salesmen. Mr. Murray, a graduate of Penn State, was for many years connected with the Carnegie Steel Company, both at the Edgar Thompson Works, Bessemer, Pa., and in the sales department. His activities will, for the most part be devoted to the steel plants in the Pittsburgh district.

An interesting development took place at the League Island Navy Yard, Philadelphia, on July 1, when the first heat of steel was made in the Greaves-Etchells furnace recently installed by the Electric Furnace Construction Company, Finance Building, Philadelphia, in the new foundry. The foundry itself is said to be one of the most modern and up-to-date in the whole of the United States, and the manufacture of steel in this yard opens up very interesting possibilities for larger future development.

Obituary

Clarence W. Hathaway, metallurgist for the last eight years for the Granite City Steel Works Branch of the National Enameling & Stamping Co., met his death by drowning while swimming with a party of friends in the Mississippi River on July 19, at Granite City, Ill. He was born in Columbus, O., in 1886, and was educated in the schools of that place and at the Ohio State University, Columbus, O. He had previously been employed with the United States Steel Corporation at Gary, Ind., before accepting his last position.

THE JOHN CRERAR LIBRARY
AUG 9 1919

The Blast Furnace and Steel Plant

Pittsburgh, August, 1919.

The Keystone Venango Gravity Grease System For Cranes, Ore Bridges, Charging Devices And Line Shafting

THE big steel plants know that the efficiency of a crane, ore-bridge, or charging device is no greater than the efficiency of its lubrication—that's why so many of America's greatest iron and steel plants use the Keystone Venango Gravity Grease System. The system which eliminates shut-downs, costly repairs, constant attention and waste of labor.

There may be a lubrication problem troubling you **right now** which the Keystone Venango Gravity Grease System will quickly solve.

Why not arrange for a trial installation at our risk and expense?

KEYSTONE
TRADE MARK
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GREASE

THE KEYSTONE LUBRICATING CO.

New York
Boston
Pittsburgh
Chicago

Executive Offices and Works:
PHILADELPHIA, PA.
Established 1884

St. Louis
Denver
San Francisco
Minneapolis
Houston

General Office and Warehouse for Great Britain: Manchester, England. Continental European Offices: Marseilles, France. West Indian Offices: Havana, Cuba. India: Calcutta, Bombay. Norway: Christiania. Italy: Turin. Egypt: Cairo. Jamaica: Kingston. Denmark: Copenhagen.